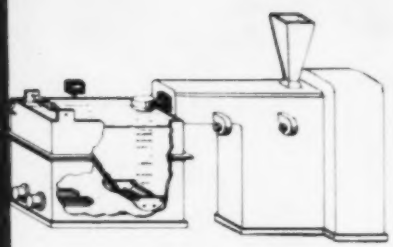
PLASTICS

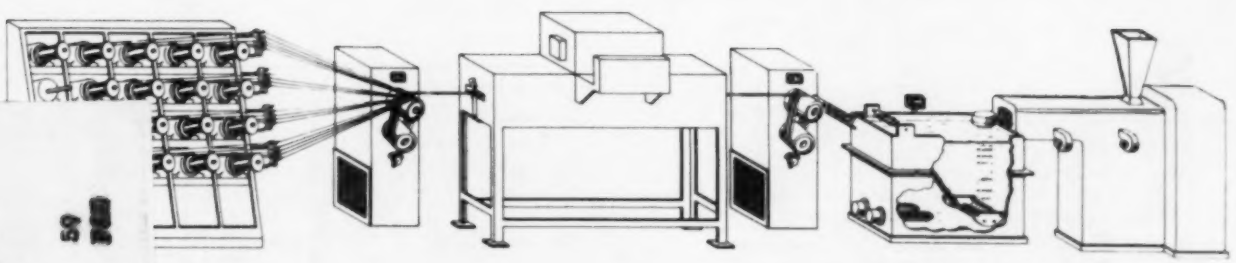
JUNE 1960

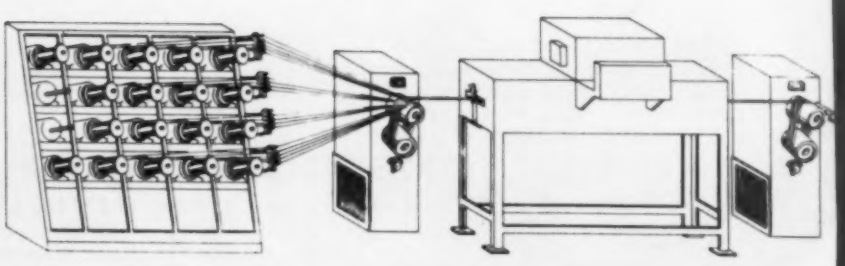
THE MAGAZINE OF APPLIED ENGINEERING

TECHNOLOGY



Polypropylene monofilament extrusion





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Epon 1001-B-80	1001	MEK	80
Epon 1001-BT-70	1001	MEK/Toluene (50/50)	70
Epon 1001-CX-75	1001	MIBK/Xylene (65/35)	75
Epon 1001-T-75	1001	Toluene	75
Epon 1001-X-75	1001	Xylene	75
Epon 1007-CT-55	1007	MIBK/Toluene (50/50)	55

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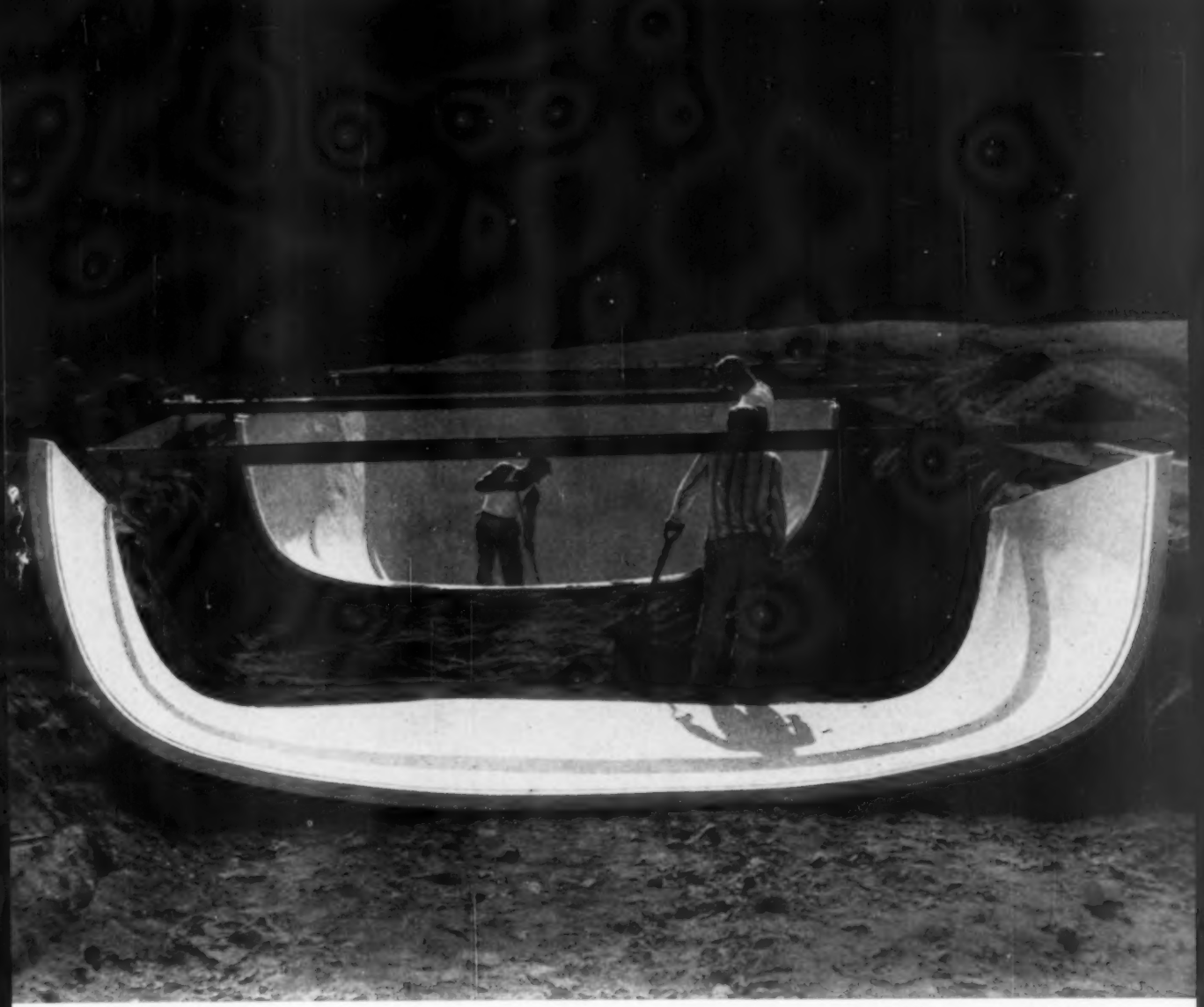

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Shipshape pools with GLIDPOL Resins

Reinforced plastic pools by Lancer, world's largest manufacturer of plastic swimming pools, are designed for carefree enjoyment with GLIDPOL GEL-KOTE and GLIDPOL lay-up resins.

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PLASTICS

THE MAGAZINE OF APPLIED ENGINEERING

TECHNOLOGY

June 1960, Vol. 6, No. 6

feature articles:

post-molding operations on acetal resin ..... p. 29

by R. L. MILLER

Because of its combination of mechanical properties, Delrin acetal resin is well suited for machining and joining (both welding and mechanical fastening) methods in post-molding operations. Machining operations are discussed in terms of recommended tools, tooling speeds, and required coolant use. The discussion of welding covers spin welding, hot-plate welding, hot-gas welding, and hot-wire welding; mechanical fastening includes coverage of press or interference fittings, snap fittings, screwing, mailing, flaring, and cementing.

effects of secondary plasticizers on processing of vinyls—II ..... p. 36

by P. D. SHARPE

A comprehensive test program was undertaken to show the advantages and limitations of secondary vinyl plasticizers. Test results discussed include fusion; compatibility; resistance to extraction in soapy water, gasoline, and oil; volatility; low-temperature flexibility; light stability; migration; odor; color; electrical properties; heat stability; flammability; and tensile properties. Proper blending of plasticizers offers optimum properties in the finished product and cost savings.

presenting creep data on reinforced plastics ..... p. 44

by E. VAN ANTWERP

Two methods for reducing "creep-rupture" testing costs are presented. One is a method for obtaining a stress vs. rupture life curve from a set of data; the other, usable when scatter is small, involves a single master curve. Rupture times may be calculated from this master curve for all test conditions which do not cause structural changes.

guest editorial:

the nature of an elastomer and a proposed definition ..... p. 43

by J. P. McMAHON

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compression and transfer molding ..... p. 48

by PAUL E. FINA

Another look at molding pressures.

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Venting of injection molds.

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exploring fabrication techniques:

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Cover diagram courtesy: Enjay Chemical Company
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Opinions expressed by contributors do not necessarily reflect those of our editors

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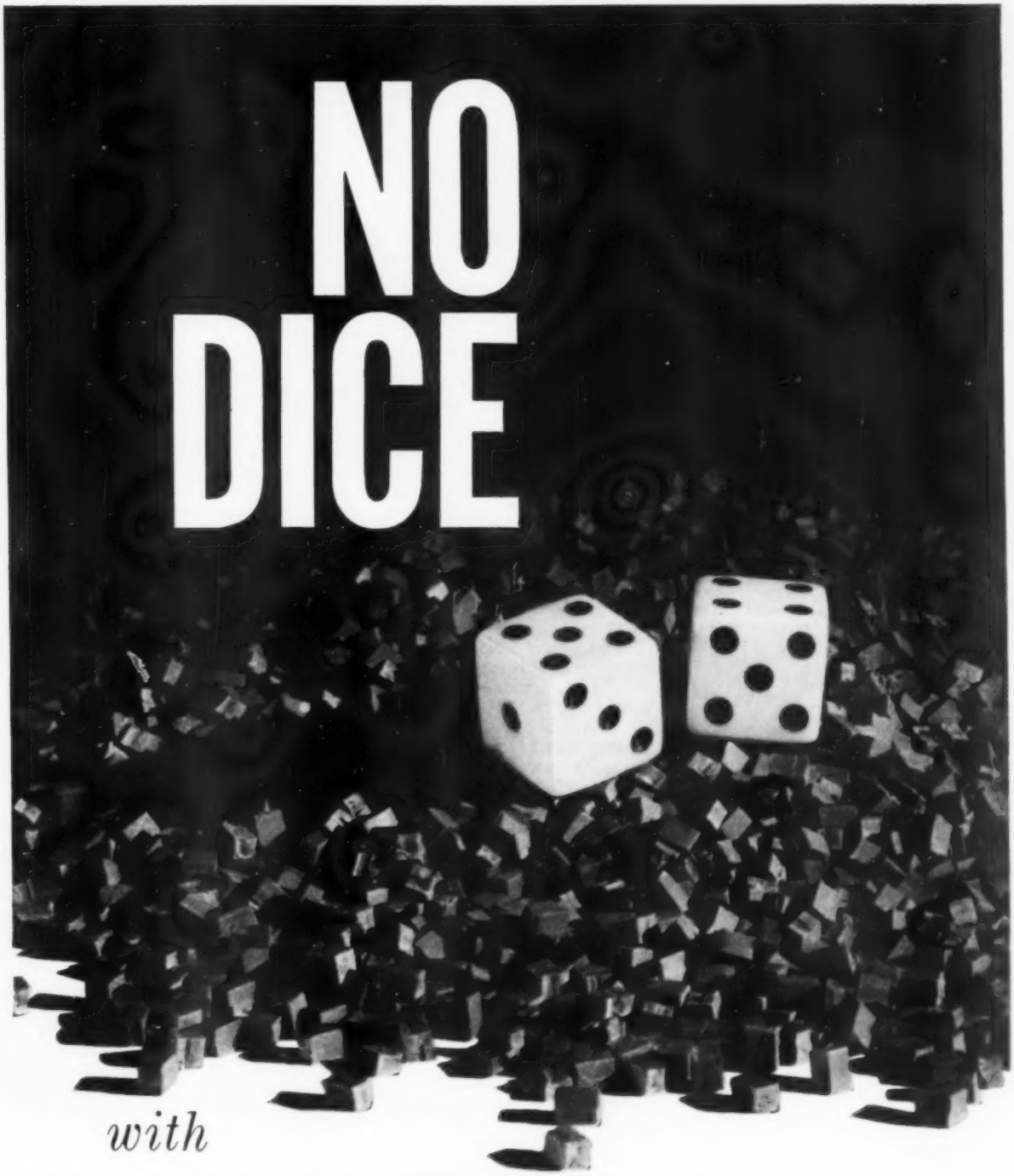

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Letters to the Editor

Injection Molding Machines

Dear Sir:

We are pleased to provide the following information on Mini-Jector plastics injection molding machines made by this firm. We regret having missed your May issue.

Three basic types of Mini-Jectors are offered. All feature low tooling cost. They mold all thermoplastics, including nylon, from sub-miniatures to 1½ ounces. Models are available with either air or hydraulic power. Vertical or horizontal clamping is offered.

Eldorado Mini-Jector offer semi-automatic and manually-operated models for high speed molding, especially of items involving inserts or loose cores. Capacity of up to 1½ ounces, vinyl. Clamping is vertical with P. E. no tie rods in front to hnder operator's free access to mold area when mold is open. Hydraulic power provides approximately 18 tons clamping pressure.

Hornet Mini-Jectors have horizontal clamping and capacity up to one ounce. Mold area (same as Eldorado models) is 6″ x 5⅛″ x 5″. Available with either air or hydraulic power.

Wasp model Mini-Jector's capacity is up to ¾-ounce. Feature small, inexpensive, self-locking "V" molds. Ideal for parts involving inserts or loose cores. Choice of air or hydraulic power. Mold blanks for Wasp models are low in cost.

We trust the above information provides your readers with some information on the Mini-Jectors.

L. W. Frohring
Newbury Industries, Inc.
Newbury, Ohio

Compression Molding Machines

Dear Sirs:

Although we are manufacturers of compression molding machines, Kingsbacher-Murphy was not listed in your February 1960 issue.

We would like to be listed in your next special on compression molding machines. Please advise us what steps we should take to accomplish this.

Sanford Beim
Hydraulic Division,
Kingsbacher-Murphy Co.
Los Angeles, Calif.

(We now have a record of this firm, and it will be contacted for inclusion in the next tabulation on Compression and/or Transfer Molding Machines. While editorial plans for 1961 have not been finalized as yet, our next compression machine special will probably appear in our February 1961 issue. —Editor)

Chemically-Resistant Containers

Dear Sirs:

Our subsidiary, S.I.A.P.A. of Rome, Italy, is looking for plastic containers for the following products:

(a). Eptachlor, DDT, Dieldrin, Parathion and Malathion dissolved in organic aromatic solvents such as Panasol AN-2, xylol, cyclohexanone, etc.

(b). Dichloroethane in admixture with a small percentage of carbon tetrachloride.

Suggestions as to possible sources for these containers would be greatly appreciated. S.I.A.P.A. is interested in containers that would be fairly elastic, not fragile, resistant to the products listed above, and impervious to organic vapors.

V. B. Sullam, U.S. Representative Office,
Italian Federation of Farmers' Cooperatives
Washington 5, D. C.

(In replying to this letter, Lee Zukor, our Engineering Editor, noted that there is no common material that is impervious to all the solvents mentioned, but suggested the following materials for test: polyethylene, both high- and low-density; Penton chlorinated polyether; Delrin acetal resin; and Teflon fluorocarbon resin. He also mentioned some data on Grex polyethylene bottles that had been tested with Shell insecticide and with dichloroethane. Finally, he suggested they test the possible use of containers made from laminated sheet stocks of Teflon-and-polyethylene or Mylar polyester-and-polyethylene.—Editor)

We invite letters from our readers for publication in these columns. Such letters may be of comment or criticism, requests for information, or of general interest. The only requirement is that all letters must be fully identified as to name of sender, company affiliation and address.

A letter will not be printed if publication is not desired by the sender, and the identity of the writer will be withheld, if desired.

—The Editor

In the Next Issue

Previews of Next Month

The July issue will feature the following technical articles:

Blow Molding—I. Fundamentals. Islyn Thomas, Pres., Newark Die Co. & Newark Plastics Machinery Corp., Newark, N. J., and N. F. Harwood, Chief Engineer, The Granbull Tool Co., Ltd., Kingston-on-Thames, England.

The start of an authoritative six-part article. This section on fundamentals describes the interest evoked by blow molding, its current status, and its outlook for the future with special note of its applications and ever-growing interest. In discussing production processes, injection blow molding and extrusion blow molding are emphasized. For extrusion blowing, special attention is given to various machinery models, their advantages and limitations; die head designs; blowing molds; and the first mention of two-color blow molding. Future sections will deal with product design for blow molding, mold design, and two-color blow molding.

•

A Feed-Screw Design for Extruding Rigid Polyethylene. Walter Mundy, Project Engr., National Rubber Machinery Co., Akron 8, Ohio and A. L. Waters, Sales Service & Development Engr., Plastics Sales Division, Phillips Chemical Co., Bartlesville, Okla.

With the advent of linear polyethylenes, the need for investigating some of the newer feed screws for extrusion became evident and imperative. A test program was set up to test screw designs for use with Marlex 6002 resin. Preliminary test results are given, and it is suggested that this work be extended by others in the plastics industry to provide similar results for other rigid polyethylenes.

•

Advances in Phenolic Materials and Processes During 1959. A. P. Landall, Mfg. of Tech. Service Engineering, Chemical Materials Dept., General Electric Co., Pittsfield, Mass.

The second in the 1960 series on Advances in the Technology of Plastics, which was squeezed out of the June issue.

•

Developments in Plastics Materials During 1959. G. B. Thayer, Plastics Specialist, Plastics Technical Service, The Dow Chemical Co., Midland, Mich.

The third in the 1960 series on Advances in the Technology of Plastics.

•

The Guest Editorial will be **"The Plastics Technical Evaluation Center — A New Project and a New Concept,"** by H. E. Prebly, Jr., Director, Plastics Technical Evaluation Center, Picatinny Arsenal, Dover, N. J.

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AND DOES—FOR BELL & HOWELL

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better lens barrel
Bell & Howell specifies

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ROLL OUT the barrel. Or roll it in, by rotating in reverse direction. The fine lens, and its threaded barrel molded of phenolics, combine to give you excellent helical focusing of slide-showings with this projector.

It's the Headliner/706 low-silhouette slide projector, a member in good standing of the famous Bell & Howell family of quality photographic equipment. Through use of a 300-watt "short" lamp, occupying far less vertical space than conventional projector lamps, the Headliner is of extremely compact design —only 7 inches high.

Among Plenco's contributions to the production of this dependable performer is the special-purpose phenolic compound specified by Bell & Howell in the molding of the projector's accurate, smooth-turning *lens barrel*. Requirements called for a material that would assure resistance to heat, dimensional stability, and surface hardness and rigidity . . . together with a lasting, eye-appealing lustre. Plenco provided the answer. Like Bell & Howell, many other manufacturers and molders find the answer to their product or production problem in the wide variety of controlled-quality Plenco phenolic compounds. And they find consultation with Plenco technicians a worthwhile preliminary. We invite *you* to take the opportunity to talk with us, soon.

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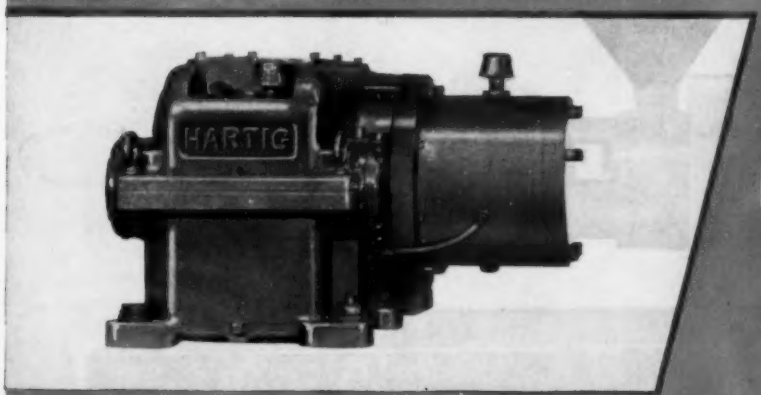

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1. Empty hopper and load with A-C Cleaning Compound.

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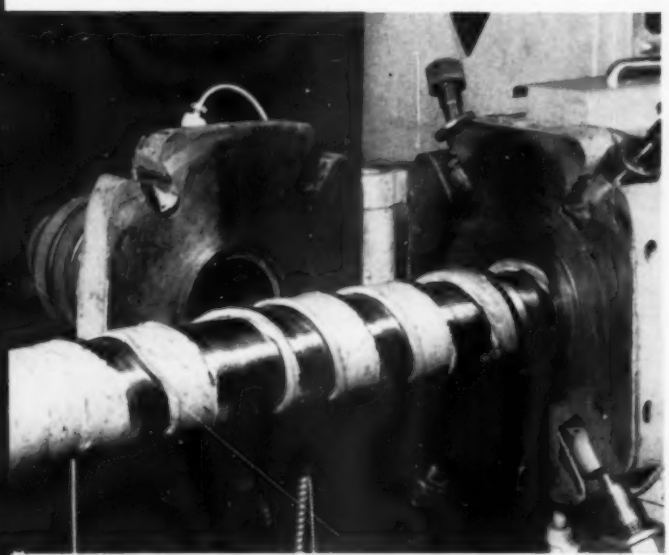
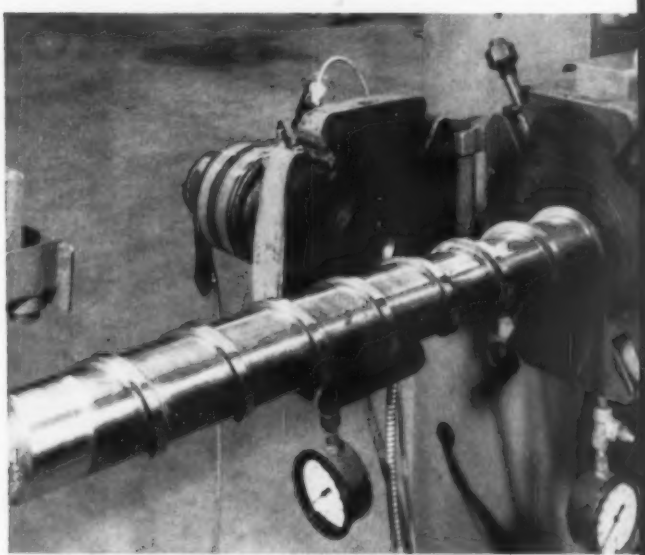


3. Note how A-C Cleaning Compound strips off easily.



4. In hours—not days—a clean machine ready for the next run!

If you've been losing days and dollars in making change-overs, here's good news! Allied's Semet-Solvay Petrochemical Division has now developed a cleaning compound that will completely remove any thermoplastic material—and do it in a fraction of the time normally required. The simple procedure is pictured above.

One extruder tells us that he saves $5,000 by using A-C® Cleaning Compound—cleans a machine in 1½ hours without tearing it down.

You'll find A-C Cleaning Compound speeds changing material or colors, and eliminates cylinder contamination. It purges without scratching and strips cleanly and easily from extrusion screws without mess.

For a free bulletin telling how this new cleaning compound can save *you* time and money, just write us at the address below.

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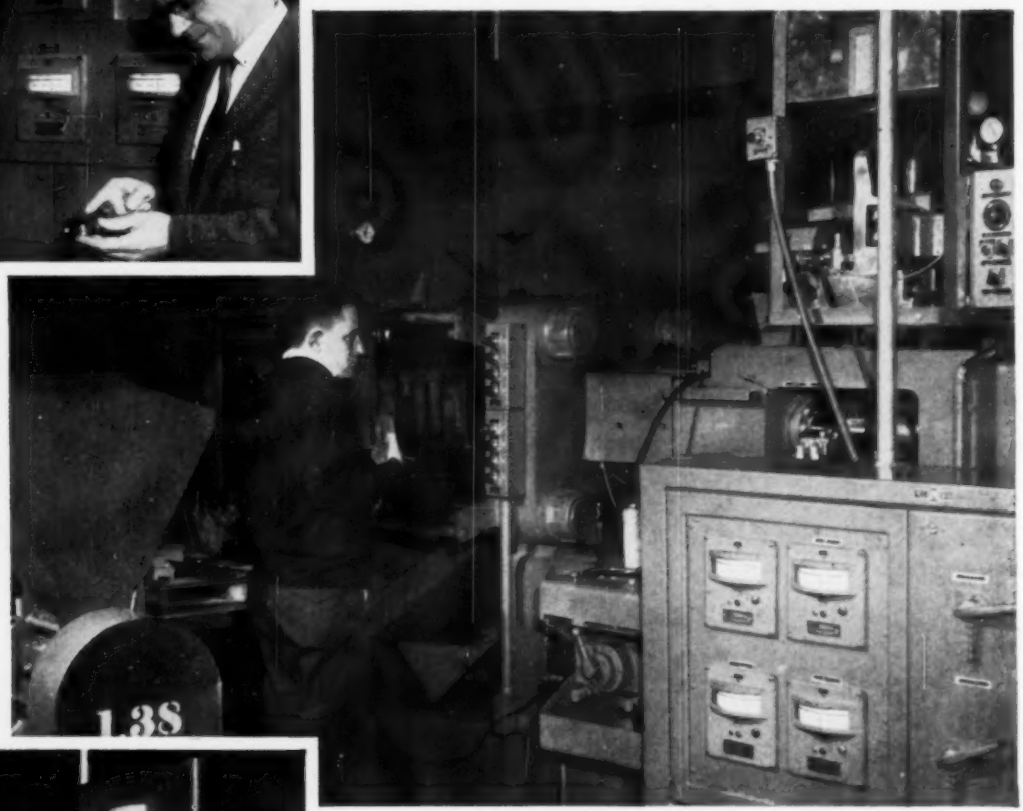

Flambeau Plastics Corporation chose
WHEELCO for FLEXIBILITY

Electronic components . . . household furnishings . . . sports equipment . . . lawn mower parts. These are but a few of the many industrial and consumer plastic products produced by the Flambeau Plastics Corporation, Baraboo, Wisconsin, with plants at Baraboo and Milwaukee. Because temperature control and instrumentation flexibility are so important to top-quality plastic products, Flambeau has specified Wheelco instrumentation for their battery of 25 injection molding machines and for their plastics extrusion department. Flambeau has found that Wheelco instruments provide the temperature accuracy necessary even for plastics having sharp breaking points. Flambeau records show a product rejection rate far lower than is average for the industry. You, too, can expect this type of instrumentation efficiency and reliability with Wheelco. Contact your nearest Wheelco sales office or write direct for complete information.

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U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE* polyethylene resins

JUNE, 1960 — U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation — 99 Park Ave., N. Y. 16, N. Y.

Packaging Notes

Molded polyethylene containers which can be hermetically sealed by automatic packaging machines are now available for frozen or chilled foods. The semi-rigid containers are reported to be useful for many applications where plastic has heretofore been inadequate due to problems of leakage or dehydration. After the containers are filled, polyethylene film is heat sealed around the reclosable lids, thus hermetically enclosing the contents of the package. A convenient pull tab is provided for initial opening.

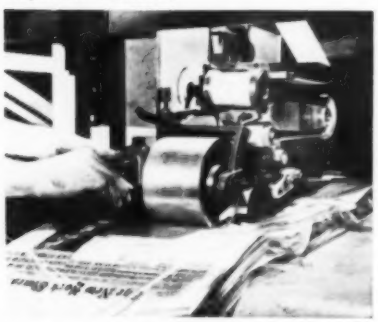
The containers are currently produced in pint and half-pint sizes. They are supplied in from one to four colors or can be left with a clear background for product visibility.

The manufacturer claims the polyethylene containers offer shipping and handling economies because they are lightweight and unbreakable.

Safety snap-on caps which fit tightly over medicine bottles, are a recent polyethylene development. They make it virtually impossible for children to get at the bottle's contents, yet adults can easily remove the caps with a flick of the thumb. The closures are said to stay secure no matter how often they're used.

Newspapers in heat-sealed polyethylene bags are now being mailed to suscribers for the first time, reports a metropolitan publisher.

Copies of the paper's Sunday edition are bagged at the rate of 1,500 per hour, using semi-automatic baggers and a continuous heat sealer. A special machine handles rolls of pre-addressed labels, coated on the reverse side with a thermoplastic adhesive.



Roll stock, pre-printed with subscriber's name and address, is automatically heated, cut, indexed and placed on the bags by the labeling attachment. The thermo-plastic coating of the label adheres firmly to the polyethylene bag.

The pre-formed 14 x 19½" polyethylene bags permit copies to be shipped flat, facilitating handling, stacking and shipping.

Newspaper officials report that the 1.5 mil polyethylene bags protect papers against rough handling, soiling, tearing and weather. They agree that the improved appearance of the paper should have an influence on customer re-orders of mail subscriptions.

U.S.I. Introduces Three New Polyethylene Blow Molding Resins

New PETROTHENE Resins Produce Bottles of Excellent Appearance, Are Easy to Process

U.S.I. has developed three new PETROTHENE polyethylene resins with properties particularly suited to individual blow molding requirements. Two of the resins can also be used for injection molding. All have been evaluated by U.S.I.'s Polymer Service Laboratories and have been successfully field tested.

PETROTHENE 101 and PETROTHENE 102-2 can be used in both blow molding and injection molding, the first in applications requiring high stiffness and good stress crack resistance, the second in applications where stiffness and impermeability to liquids, oils, and gases is important. PETROTHENE 209-2 is designed for use in blow molding, especially for relatively small moldings with thick side walls.

Each of the resins is easy to process and produces bottles of outstanding appearance, good stress crack resistance and excellent low-temperature flexibility.

Lower Cost Per Container

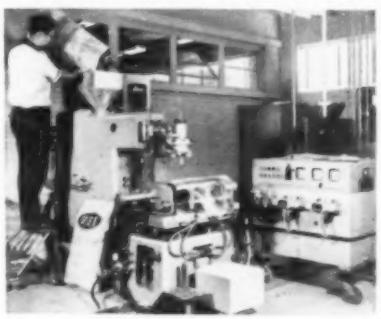
High stiffness and good stress crack resistance are the key characteristics of PETROTHENE 101 (density–0.924, melt index–2.0). This permits a reduction in wall thickness and consequently, a lower cost per container. Its torsional modulus of elasticity is approximately 18,000 lb/sq in. higher than the best of three other similar polyethylene resins commonly used for blow molding.

The stress crack resistance of PETROTHENE 101 was tested in an accelerated shelf-life test by filling thin-wall tubes molded of the resin with a commercial detergent and holding them at 120°F for 4 months. There were no container failures even though the metal closures were beginning to show signs of corrosion.

Carboys For Chemicals

High flow rate is the key characteristic of PETROTHENE 102-2 (density-0.924, melt index-2.0). This makes the resin particularly useful in blow molding pieces 6 to 20 oz. or heavier.

Because PETROTHENE 102-2 is also highly impermeable to liquids, oils and gases, it is a desirable resin for blow molding large carboys for liquid chemicals. However, normal precautions should be observed in producing containers for chemicals which act as stress cracking agents.



Extrusion blow molding machine in operation at U.S.I.'s Polymer Service Laboratories, used for evaluating the new PETROTHENE molding resins.

Small Bottles a Natural

The excellent low-temperature flexibility of PETROTHENE 209-2 (density 0.920, melt index-3.0) makes it ideal for bottle blowing where the moldings are relatively small–under 10 oz.–and have thick sides. Its stress crack resistance is comparable to that of competitive resins used for the same applications. In field evaluations, cycle times with this resin were found to be faster than those of comparable resins. Yet seal strength at the parison pinch-off point–often a problem when blow molding cycles are shortened–is good.

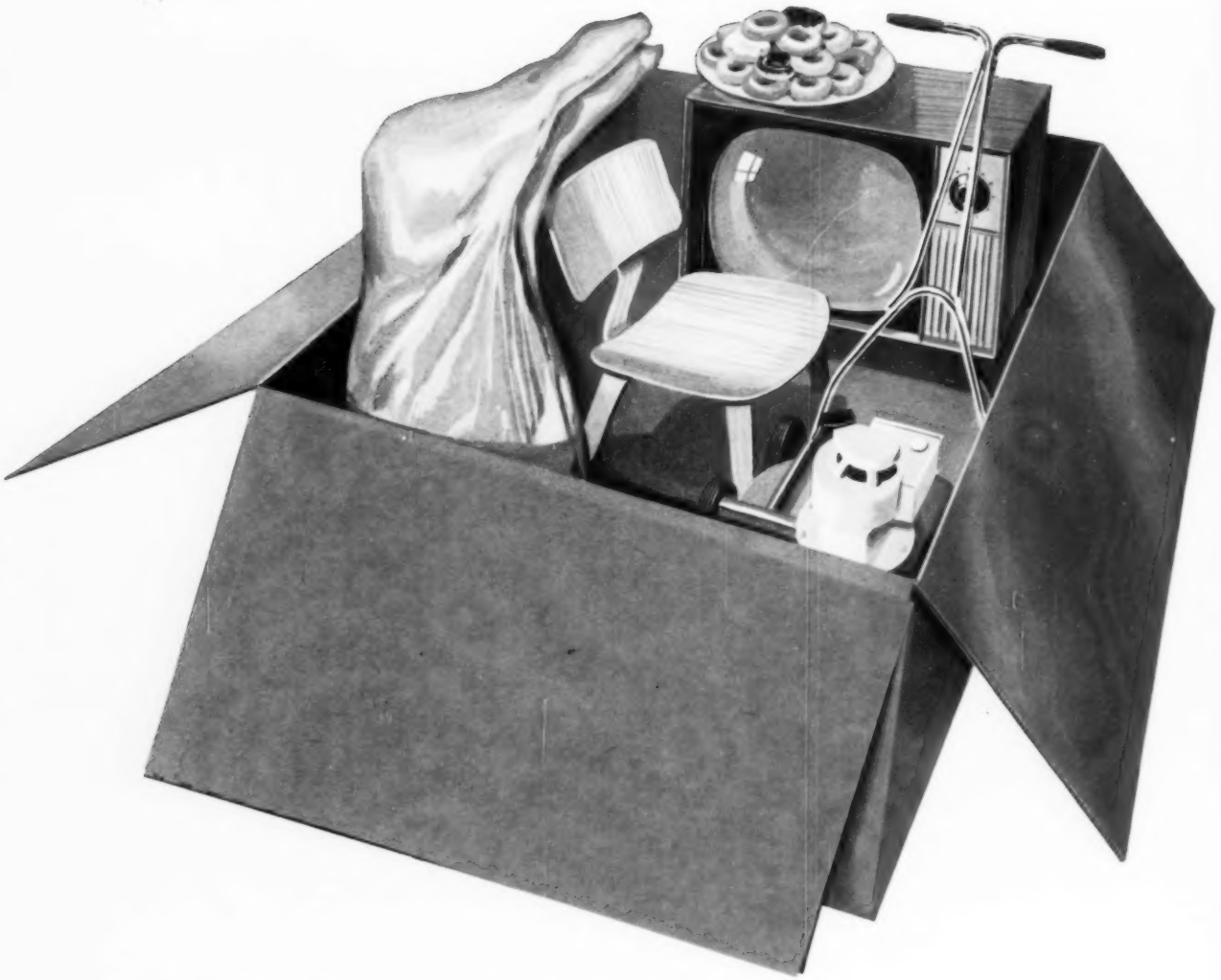
Data Available On Silk Screen Printing Machines

A manufacturer of machines for direct printing on polyethylene bottles and other containers is offering a brochure describing the company's line of equipment. The machines, which are automatic and semi-automatic, can print on flat, cylindrical and conical surfaces, and even on objects of awkward shapes. Multicolor printing is possible by printing one color and allowing it to dry before applying the next.

New Twin-Station Machine For Versatile Blow Molding

A new twin-station blow molding machine which permits simultaneous operation with either identical or different molds has been developed. For example, a toy can be blown in one station at the same time a two-quart bottle is being blown in the second station.

The machine's capacity is large, accommodating molds up to 36" by 21" wide and 28" daylight with a 12" stroke. Equipment is said to be safe, simple and low in cost to operate and maintain.



exceptional moisture and grease resistance

POLYETHYLENE-COATED KRAFT OPENS UP NEW OPPORTUNITIES FOR CORRUGATED BOARD

Polyethylene-coated corrugated board — produced on conventional corrugating equipment—is extending the usefulness of corrugated into many new packaging applications.

This unique container board has exceptional moisture and grease resistance and a glossy, non-abrasive liner surface that will not scratch or mar package contents.

Extruders who produce polyethylene-coated kraft liner board can get these extra advantages by using U.S.I. PETROTHENE® polyethylene resins:

HIGH PRODUCTION RATES—PETROTHENE resins have good drawdown properties, permit extrusion at high speeds.

EXCELLENT ADHESION — with minimum hot melt oxidation.

NO ODOR — an important consideration in many packaging applications.

Contact U.S.I. for information on PETROTHENE resins especially suited for coating kraft liner board.

Packagers are investigating polyethylene-coated corrugated board for applications like these:

Bulk shipment of meat, where moisture and grease-proof interiors reduce weight loss of the meat and keep moisture from weakening the carton.

Shipment of furniture and other hard goods, where abrasion damage from the container has been a problem.

Bulk bakery and confectionery shipments, where absence of grease-wickage makes containers suitable for reuse as point-of-sale displays.

In concrete construction forms, where the polyethylene coating acts as a release agent.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

NEW! "XL-modified"

NLC Stabilizers upgrade performance of proven vinyl insulations

Aid color, simplify processing, too!

Today, everyone from the electrical contractor to the missileman wants to cram more power through wire with thinner vinyl insulation. This means the manufacturer must continue to produce better and better vinyl insulation.

Now, from National Lead Stabilizer research, comes word of a significant development in this direction . . . a modification applicable to five of the eight National Lead Stabilizers widely used for insulation. These are DYTHAL®, DYPHOS®, LECTRO® 60, TRIBASE* and TRIBASE-E* Stabilizers.

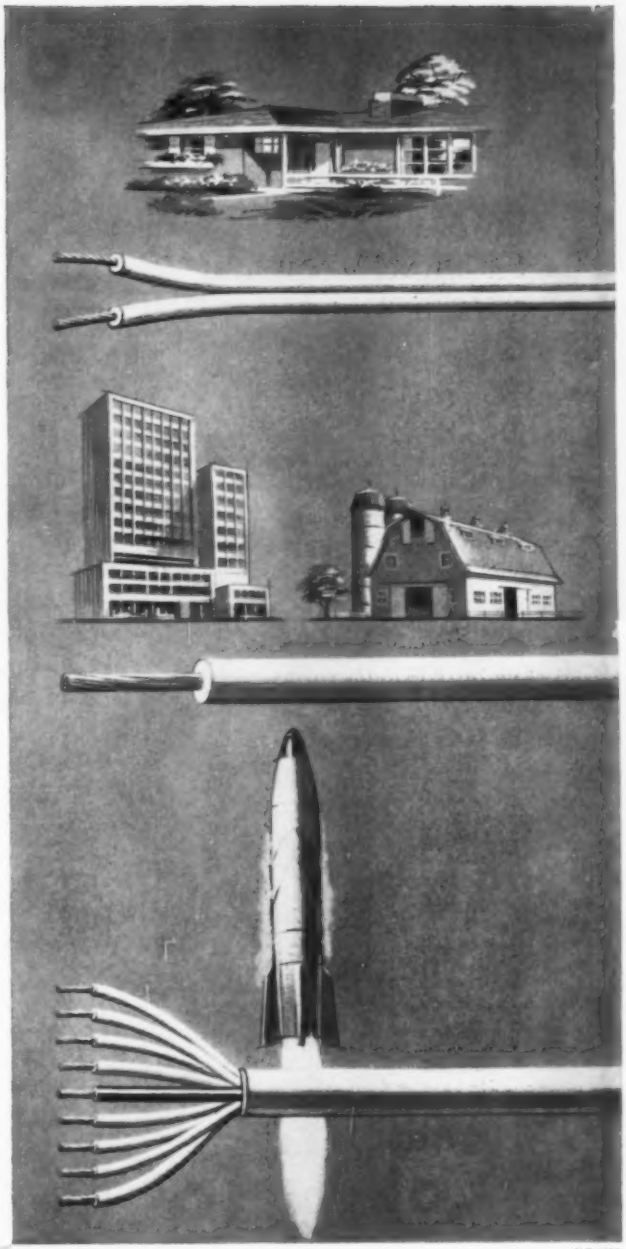
This modification greatly improves the effectiveness of the stabilizer in dielectric vinyl compounds and raises the performance level of the insulation. To designate the modified stabilizer the letters "*XL*" are used. For example, the modified *Tribase Stabilizer* is *Tribase XL Stabilizer.*

The new "XL" Grade Insulation Stabilizers call for no changes in proven formulations, yet with them, the *performance* of your proven formulations can be markedly improved.

The "XL" Grade Insulation Stabilizers produce the following improvements:

1. **Increase heat stabilizing action.**
2. **Increase retention of desired physical properties in the insulation during heat aging.**
3. **Improve natural color of compound both initially and after processing and aging.**
4. **Step up on-wire electrical resistivity.**
5. **Ease processing . . . particularly extrusion.**

Information on the new "XL" Grades is provided in a new NLC data sheet. If you would like a copy, simply let us know with the coupon below.



KC-6792

National Lead Stabilizers for Vinyl Insulations

(➤ indicates stabilizers available in both standard and "XL" grades)

- ➤ DYTHAL® Stabilizer for all classes up to 105°C primary insulations.
- ➤ DYPHOS® Stabilizer for top-notch light-and-weather-resistant jacketing.
- ➤ LECTRO® 60 Stabilizer provides economy in 60°C and higher-rated vinyls.
- ➤ TRIBASE* Stabilizer is the quality heat stabilizer up through 90°C insulations.
- ➤ TRIBASE-E* Stabilizer is the general purpose heat stabilizer for primary insulation.
- LECTRO® 77 Stabilizer meets requirements up through 80°C insulations.
- LECTRO® 78 Stabilizer improves special high-temperature stocks including vinyl tapes.
- DS-207® Stabilizer-lubricant improves heat stability and extrusion characteristics.

*Trademark

NLC **National Lead Company:** General Offices: 111 Broadway, New York 6, N. Y. In Canada: 1401 McGill College Ave., Montreal.

Gentlemen: Please forward your new data sheet on "XL" Grade National Lead Company Stabilizers for vinyl electrical insulations.

Name _____ Title _____

Firm _____

Address _____

City _____ State _____

"XL" Grade Insulation Stabilizers

A Chemical Development of

National Lead Company

General Offices: 111 Broadway, New York 6, N. Y.

CORROSION RESISTANCE...

...another way high-density polyethylene IMPROVES YOUR PRODUCT

DRAINAGE WATER CONTAINING harsh detergents and common corrosives can be a problem for sump pumps, but Fostoria Corporation's new submersible "Dynasump" is highly resistant to household chemicals. An integral component of this non-corrosive construction is the combination cover-strainer molded of BAKELITE high-density polyethylene DMD-6001.

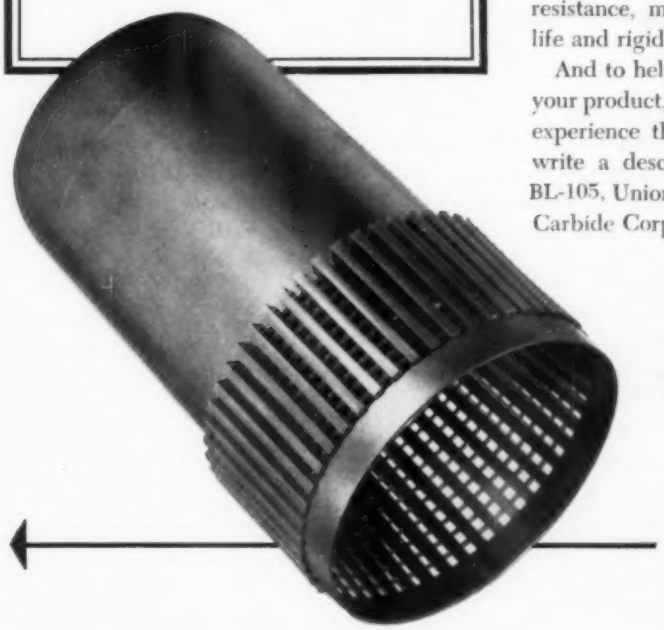
Tough and rigid, this high-density polyethylene also contributed to Fostoria's new design concept. These properties, along with the excellent molding characteristics of DMD-6001, made this complex, one-piece molding possible; details are clean and sharp. The result is a durable, functional, good-looking part that meets every requirement at low cost.

Finding the right combination of polyethylene properties is made easier by the variety of BAKELITE Brand polyethylene formulations available today. In addition to the low, medium, and high densities, the list also includes the remarkable new polyethylene copolymers. Such properties as stress-cracking resistance, moldability, dimensional stability, toughness, flex life and rigidity can be specified in the degree you require.

And to help in applying the properties of these materials to your product, you can call on the same technical knowledge and experience that developed them. Mail the coupon today, or write a description of your requirements directly to Dept. BL-105, Union Carbide Plastics Company, Division of Union Carbide Corporation.

TYPICAL PROPERTIES OF DMD-6001

Properties	ASTM Test	Typical Value
Density, gm/cc	D 1505	0.950
Melt Index, gm/10 min.	D 1238	2.0
Tensile Strength, psi	D 638	3,400
Elongation, %	D 638	45
Secant Modulus (Stiffness), psi	D 638	100,000
Hardness, Durometer "D"	D 676	60



Fostoria "Dynasumps", designed for rigorous underwater service, are housed in covers molded of BAKELITE Brand high-density polyethylene DMD-6001. The cover-strainers are molded by Haas Corporation, Mendon, Michigan.

"Bakelite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

UNION CARBIDE

Dept. BL-105
Union Carbide Plastics Company
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N.Y.

Please send me information on BAKELITE Brand high-density polyethylenes with particular emphasis on these properties .....
the application being considered is .....

Name_____

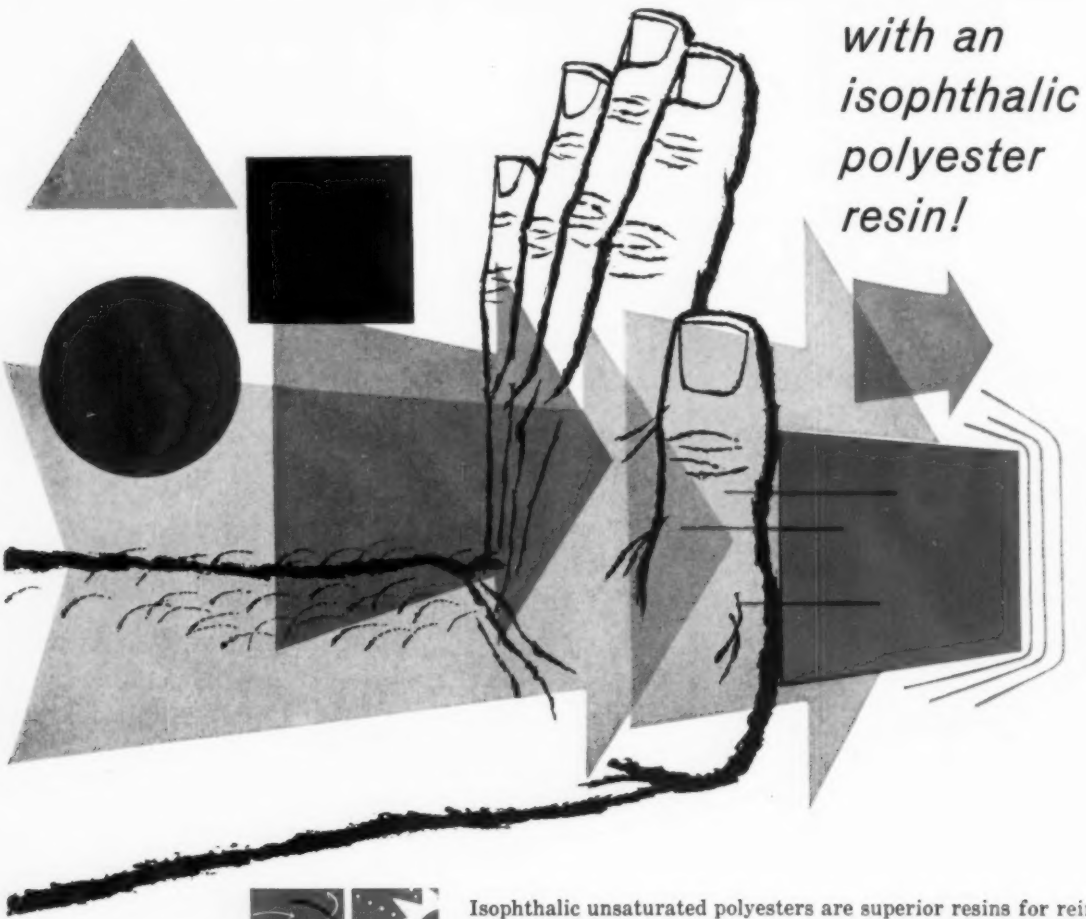
Firm name_____

Street_____

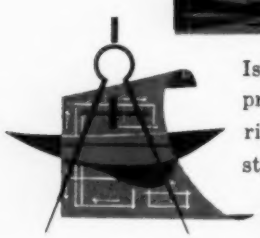
City_____ State_____

Push your product **OUT FRONT**

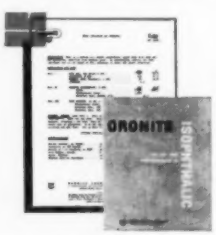
with an isophthalic polyester resin!



Isophthalic unsaturated polyesters are superior resins for reinforced plastics products — providing greater physical strength, impact resistance; improved flexibility and adhesion; better heat distortion properties — *on exposure to time, temperature, water and weather.*



Isophthalic polyester resins offer manufacturers, designers, engineers and production people improved properties for planning better products to more rigid specifications and convenient production methods. More attractive product styling, better performance and greater reliability are all now possible.



Ask your resin supplier about Isophthalic polyesters or request Isophthalic polyester information and formulations from Oronite. Just contact the Oronite office nearest you.

ORONITE CHEMICAL COMPANY
A CALIFORNIA CHEMICAL COMPANY SUBSIDIARY

EXECUTIVE OFFICES • 200 Bush Street, San Francisco 20, California
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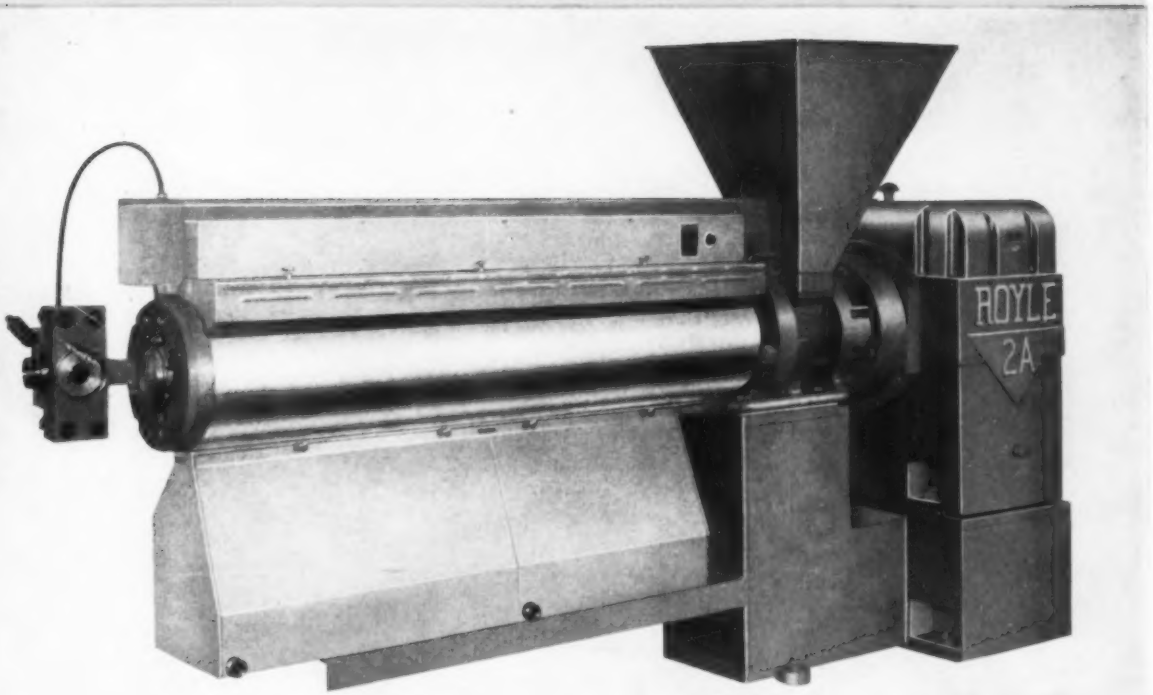
6409

Royle brings you

FASTER PRODUCTION WITH LESS WASTE



Royle Spirod Extruders are expressly designed for high speed Vinyl Extrusions. At the same time, they assure you quality controlled production not before obtainable.

The engineering advances that bring you these benefits are exclusively Royle's: high output at high stock screw speeds, due to longer length to diameter ratios; and extremely efficient evaporative cooling.

Longer L/D screws provide greater plasticizing ability, while evaporative cooling at any point on the cylinder removes the excess frictional heat generally associated with high stock screw speeds.

As they have been since 1880,
Royle is first in Extruder development.

ROYLE
Paterson, N. J.

JOHN ROYLE & SONS

Pioneered the Continuous Extrusion Process in 1880

London, England, James Day (Machinery) Ltd., Hyde Park 2430-0456. **Home Office,** V. M. Hovey, J. W. VanRiper, SHerwood 2-8262. **Akron, Ohio,** J. C. Clinefelter Co., BLackstone 3-9222. **Downey, Cal.,** H. M. Royal, Inc., TOpaz 1-0371. **Tokyo, Japan,** Okura Trading Company, Ltd., (56) 2130-2149.

John Royle & Sons, 6 Essex Street, Paterson 3, N. J.

Please, send me full information about Royle High Speed Vinyl Extruders.

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

Joe Foster, President, suggests the range of Foster Grant's engineering services.

"Design molds for a resin customer? Sure, and we'll production-prove them for you, too," says Joe Foster.

Not that designing molds is our business.

Basically, we're suppliers of polystyrene, impact polystyrene and Nylon 6 resins, and we're also the world's largest manufacturer of sunglasses. But quite often a customer takes us up on our standing offer — of technical assistance in any area, from materials and machines to packaging and marketing.

Take last Fall, for instance. One of our customers was in Leominster, so we invited him to drop over and see our facilities. He molds combs, and one glance convinced him that some of our ideas might make his operation more productive.

We then offered to furnish him an improved mold, designed for his needs and tested by us **on his own machines.** Result — he now gets 16 combs per "shot" instead of 8, semi-automatic instead of hand de-gating, and a 26% shorter cycling time. No more grinding or buffing, either... for a yearly saving of more than $100,000!

Why not see if our engineering services can help **you.** Call or write us today. Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511.

FG

FOSTER GRANT

Your Partner in Plastics Progress

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in principal cities

Customers "feel" for quality in vinyl outerwear

That's why a fine "hand" is so important for vinyl fabrics. And, many producers are convinced that Plastolein Low-Temperature Plasticizers endow their products with the very best hand . . . the soft, suppleness that "makes friends" with the buyer right from the start.

These Plastolein Plasticizers keep him sold, too, by maintaining this fine hand at all temperatures, particularly throughout the chill range. And not for just a few months but *for many seasons* . . . even after prolonged exposure to summer heat.

Emery offers two outstanding low-temperature plasticizers: Plastolein 9058 DOZ, the ultimate in low temperature performance; and Plastolein 9078 L.T., its lower priced counterpart.

Write Department Q-6 for literature.

PLASTOLEIN® plasticizers

Emery

Organic Chemical Sales Department

Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio • Vopcolene Division, Los Angeles—Emery Industries (Canada) London, Ontario—Export Department, Cincinnati

Sound Suggestion

Radio shells and other plastic products gain built-in sales appeal with Glidden Zopaque® Titanium Dioxide

Plastics depend on Glidden Zopaque for the whiteness and brightness that attracts more attention at the point-of-sale.

Zopaque exhibits outstanding optical properties—high opacity, hiding strength and tinting power. It is readily dispersible in plastic formulations.

Write now for full information on how Glidden Zopaque Titanium Dioxide can provide extra benefits for your products.

QUALITY Glidden PRODUCTS

FINEST PIGMENTS FOR INDUSTRY

The Glidden Company
Chemicals—Pigments—Metals Division
Baltimore 26, Maryland

(This advertisement is printed on paper stock containing Glidden ZOPAQUE Titanium Dioxide.)

This Month in Brief

Two feature stories worthy of attention in this issue; "Plastic Radome Noses" and "Extruded Diffuser Helps Solve Museum Lighting Problem." Each describes an interesting plastics development of interest as illustrations of properly-engineered plastics applications.

This month's Guest Editorial, by J. P. McMahon, merits your serious consideration in view of the controversy between ASTM Committees D-11 and D-21 in trying to work out a logical and equitable separation between rubbers and plastics. We invite all our readers to express their thoughts on this subject to guide our editorial opinions.

The Editorial this month repeats our standing invitation to the readers that they take advantage of our Guest Editorial columns to air their opinions, thoughts, ideas, gripes, or what-have-you that would warrant publicity and further dissemination to our readership. Space requirements for Guest Editorials are given. Note that the Guest Editorials are not subject to any censorship on our part!

Polypropylene, the fairhaired plastic resin, is the subject of this issue's engineering section, Exploring Fabrication Techniques. Lee Zukor, our Engineering Editor, discusses the principles involved in polymerization of propylene, and explains some of the differences inherent with current polymerization methods. Going into the processing techniques, Lee describes the extrusion of polypropylene monofilament, and how the monofilament is oriented after extrusion.

Some notes on the Feature Articles in this issue follow:

The lead article, "Post-Molding Operations on Acetal Resin," presents the first comprehensive treatment of machining and joining methods that can be used after molding of Delrin acetal resin.

"Effects of Secondary Plasticizers on Processing of Vinyls -- II" concludes this important discussion on secondary plasticizers that will be of major interest and value to all processors of vinyls.

"Presenting Creep Data on Reinforced Plastics," compares two different methods of presenting creep data and points out limitations and advantages.

Three Engineering Forum columns this month: Compression & Transfer Molding; Consultants' Column; and Injection Molding. The first, squeezed out of the May issue, gives another look at compression molding pressures and how they can be determined. The second, new in this magazine, introduces the two consultants, describes the scope of their Forum, and invites questions from the readers that they will answer in the future. The third is a guest contribution from Ernie Moslo and covers an interesting aspect of injection molding.

Product-Design
BRIEFS
from Durez

MIND OVER MOTOR

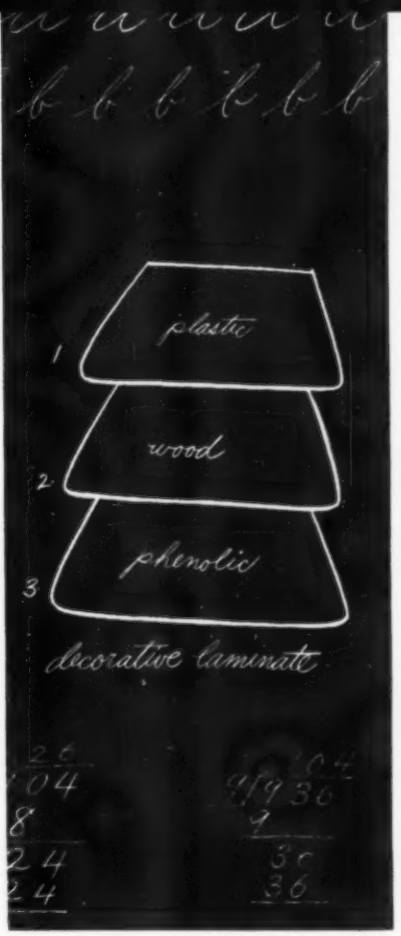
This phenolic fan will help an electric motor run cool and quiet for years to come.

It won't warp out of shape if the motor toils for hours in the hot sun or sits idle for days in a damp cellar. It won't rattle or hum.

To the men who make the motor, it means a better product; the right blade contour with no machining. Precise concentricity and balance, molded in. Light weight.

Perhaps you could use these advantages of Durez phenolic in one of your products. Your custom molder will be glad to talk with you about it.

THE BROWN-BROCKMEYER CO.



DECAR PLASTIC CORPORATION

LESSON IN LAMINATES

Think back—to a classroom of desks with varnished ink-stained tops gouged with the initials of your predecessors.

Then think ahead, as the makers of school furniture are doing. They use tough plastic Decarlite desk-top sandwiches—laminates that take pupil punishment in stride. The best of these have a layer of Durez phenolic in them.

Lesson for today: if you want a laminate to be stiffer and harder, to be dimensionally stable, to last longer and hold its shape better, think of Durez phenolic resins. They're low in cost. They bond, impregnate, harden—and stay that way for keeps. If you'd like to know more about what these versatile resins can do for you, write us describing the problem.

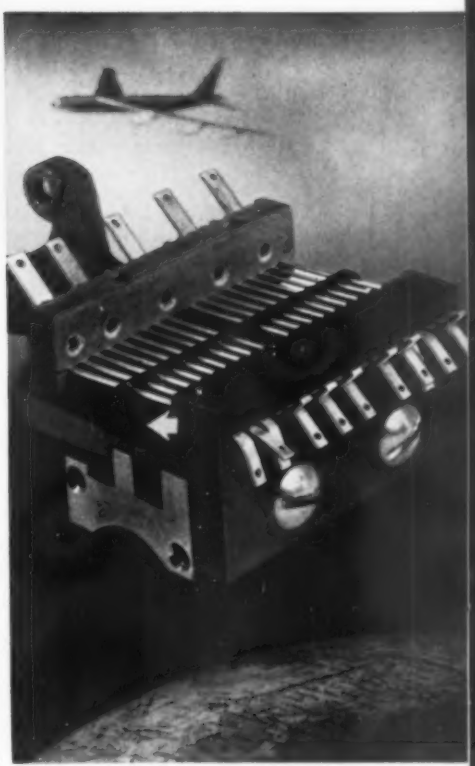
BRAIN FOR A BOMBER

This is a read unit of a latitude data computer, part of the B-52's intricate bombing-navigation system made by IBM.

Engineers had trouble molding one part (arrow). They were using a plastic which required a high molding pressure. This high pressure damaged the steel part of the pin assembly by forcing it into the locating portion of the mold.

A switch to a Durez diallyl phthalate molding compound was the answer. This material molds at lower pressures and provides the right physicals with virtual freedom from cold flow and creep.

When you want reliability in a system—with no room for compromise—a Durez diallyl phthalate compound may be your solution, too. For data on these premium-quality materials, write us or check the coupon.



IBM FEDERAL SYSTEMS DIVISION

For more information on Durez materials mentioned, check here:

- ☐ Phenolic molding compounds—descriptive Bulletin D400
- ☐ Phenolic resins—illustrated bulletin describing uses
- ☐ Diallyl phthalate molding compounds—data sheets

Clip and mail to us with your name, title, company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

8606 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

What's new in processing

Enjay Chemical Co. has been very much in the news this month and, from the processing viewpoint, claims a superior process for the production of polypropylene. Developed by Esso research, this process is said to permit a greater yield using a small amount of catalyst which, incidentally, can be recovered in greater amounts. The process is a continuous one, rather than batch, and involves the treating of propylene gas with both catalyst and solvent.

A "spot-bonding" technique for attaching Teflon to itself or other materials has been developed by Plastic Associates' Laguna Beach, Calif. While not eliminating the adhesive, it sharply reduces the amount required and thus preserves Teflon's low-loss characteristics. A treating agent called Tetra-Etch is applied to selected portions of the surface, creating a carbonaceous film in those areas. A general-purpose epoxy bonding agent is applied to these spots and the components assembled. Both treating and bonding agents are available from the firm in special kits, designated PA-746.

Incorporating gold reflective cloth as part of the reflector structure is said to provide an economical method for producing reinforced plastic radar reflectors. The reflectors, measuring 6 by 10 feet were developed by Lockard Tool & Engineering Co., Lynwood, Calif., in cooperation with Gilfillan Bros. of Los Angeles. The cloth not only eliminates the metal spraying operation, but lends itself very well for incorporation into the physical structure of the laminate. Standard fabrication methods are used, employing vacuum bag techniques.

General Electric has come up with a new method for making and securing the complex stator winding connections on large induction motors. Two rings or "harnesses" of insulated conductors are encapsulated in epoxy. Short leads emerge from one at precise points for making the series connections among the various coils. Entrance cable connections are included within the ring, and need not be hand made during assembly. The second harness contains connections for equalizing phasa unbalances and suppressing harmonics. A patent is pending on the system, which is said to provide simpler and more reliable connections, uniform for all machines of a given type and rating. Encapsulation prevents conductors from rubbing together and thus abrading their insulation. Individual stator coils can be removed and replaced as easily as before. The system is being used on all G-E two-pole boiler feed pump motors, 1,500 hp. and above.

Abstracts

"Cellit Sintering Powder for Whirl Sintering Process" by E. Rohm and H. Glassner appeared in the October, 1959, issue of Kunststoffe. Natural or colored Cellit butyrate powder can be whirl-sintered to metal, ceramic, or wood surfaces. Methods are described.

"Manufacture of Clear Film from High Density Polyethylene by Water Bath Quenching" by E. Overage and G. John, British Plastics, November, 1959. Evenly plasticized material is extruded vertically downward into a temperature-controlled water bath to give film of high clarity and sparkle. These films are said to resemble regenerated cellulose in these respects.

"Plastic Molds for Molding Plastics and Rubber" by J. J. Berthelot in the November, 1959, issue of Industrie Plastiques Modernes. The text accompanying a film on the making of injection and thermosetting molds from Devcon C.

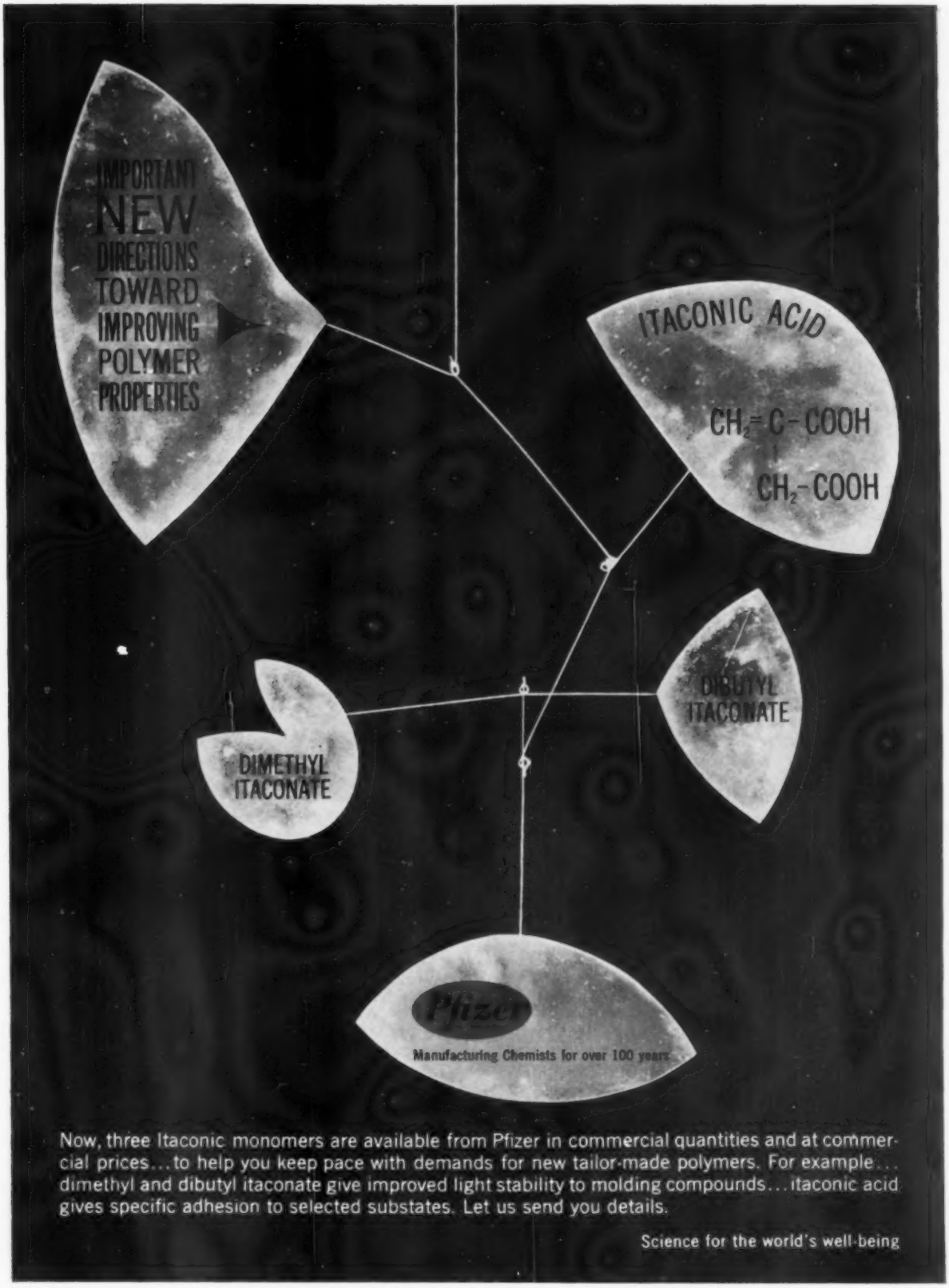
"Production and Application of Spraying Foam Based on Carbamide Resin" by E. Weber in the August, 1959, issue of Kunststoff-Rundschau. The resin is sprayed in-situ from a portable machine.

"Extrusion of Unplasticized PVC Film" by A. E. Parker, British Plastics, October, 1959. The process is carried out on a 45-mm. Reifenhauser machine with standard film-blowing head only slightly modified. Film is clear, and the properties of the compound required are discussed in detail.

Patents

2,927,623 to Filon Plastics Corp.—covers several aspects of continuous reinforced-plastic panel production plus machinery not covered in the original patent.

2,885,777 G. Gliss to Western Electric—a method of applying thin-walled (0.2 mil) insulation to copper filament. Polyethylene is extruded under high pressure upon an advancing copper filament and both are drawn through a die with a constricting aperture.



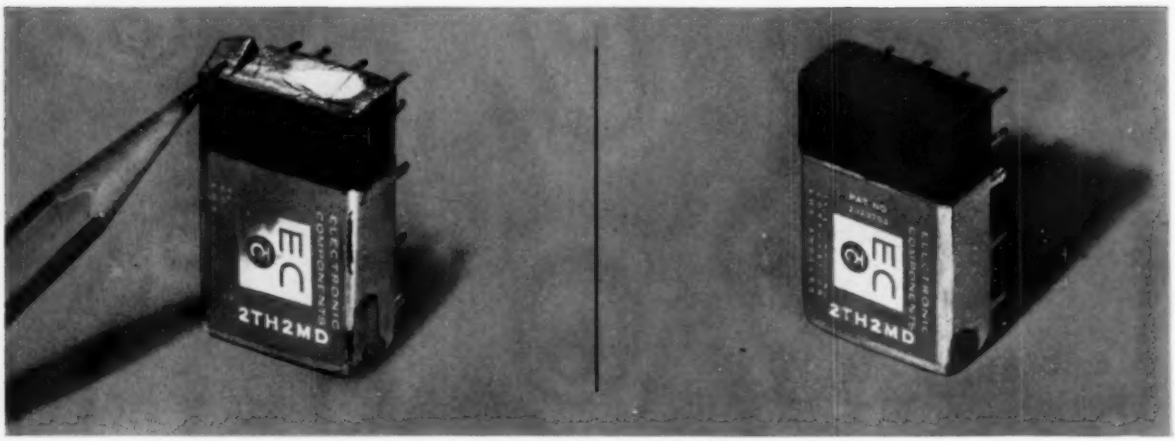
Now, three Itaconic monomers are available from Pfizer in commercial quantities and at commercial prices... to help you keep pace with demands for new tailor-made polymers. For example... dimethyl and dibutyl itaconate give improved light stability to molding compounds... itaconic acid gives specific adhesion to selected substates. Let us send you details.

Science for the world's well-being

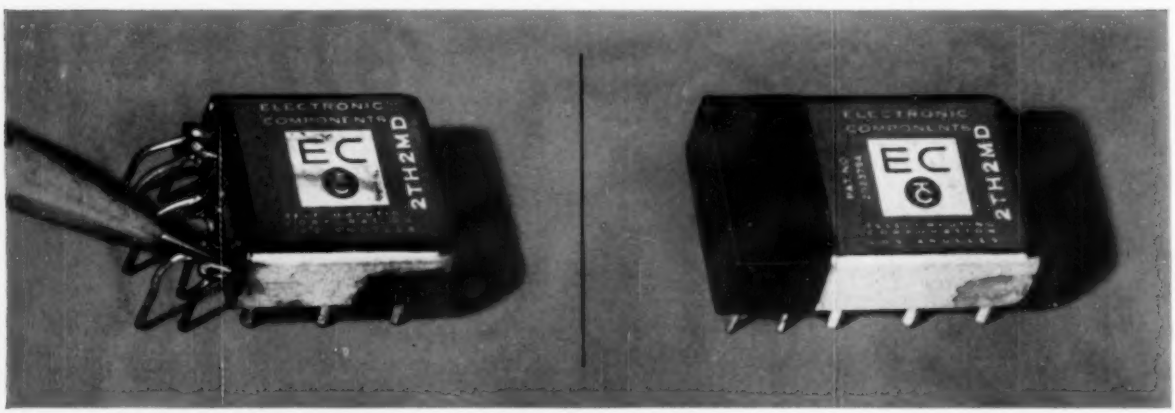
Chas. Pfizer & Co., Inc., Chemical Sales Division, Commercial Development Department, 630 Flushing Avenue, Brooklyn 6, N. Y.

Branch offices: Clifton, New Jersey; Chicago, Illinois; San Francisco, California; Vernon, California; Atlanta, Georgia; Dallas, Texas; Montreal, Canada

DOW | THERMOSETTING RESINS



Under 180°C. heat, the ordinary epoxy resin cracked . . . but the epoxy novolac potting was unharmed!



In an epoxy stripper, the epoxy resin potting dissolved . . . but the epoxy novolac showed no significant change after two weeks' immersion!

DOW EPOXY NOVOLAC UNHARMED

by brutal heat and chemical torture tests!

Tests conducted by an electronics component manufacturer prove it! Compared on the basis of their ability to withstand extreme heat and powerful chemical attack, these two miniature relays demonstrated the amazing difference between a regular high-quality epoxy resin, and Dow epoxy novolac resin (D.E.N. 438).

The test to determine the effects of prolonged intense heat on these two terminal pottings took place in a 180°C. oven. After five hours, the ordinary epoxy resin potting compound cracked. But after 100 hours of continuous 180°C. heat, the Dow epoxy novolac was unharmed!

A chemical resistance test compared the ability of each potting compound to withstand the action of high-powered stripping solvents similar to solvents used in cleaning electronics equipment. The ordinary epoxy resin formulation was completely dissolved after only 48 hours in the stripper. But the Dow epoxy novolac potting showed no significant change, even after two weeks' immersion!

These results prove once again that in potting, molding, encapsulating and laminating, or in any application where performance is critical, Dow epoxy novolac resins can provide the extra measure of physical and chemical stability necessary for success.

New applications for the complete Dow family of thermosetting polymers are being uncovered every day. If you have a problem that could benefit from their hardness, toughness, dimensional stability, and chemical resistance, call your nearest Dow sales office. Or write: THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1965DT6.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Editorial: Guest Editorials Invited

A standard feature of PLASTICS TECHNOLOGY since its inception has been the monthly Guest Editorial contributed by company spokesmen or other individuals in the domestic plastics industry.

Some of our Guest Editorials to date have been unsolicited and, in fact, even unexpected. Others, on the other hand, resulted from our invitations to the authors that they expand or enlarge on comments they had previously made in letters or phone conversations.

In line with the editorial changes and improvements being made in the magazine this year, we would like to discuss the Guest Editorials in greater detail.

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We look upon Guest Editorials as providing a sounding board whereby any responsible person in the plastics industry, speaking either for himself or on behalf of his company, can express any thoughts or opinions meriting attention by our readership.

Interest to the readers is the only requirement. Guest Editorials can be on any subject, technical or non-technical, but it should be noted that our readers are essentially technical in nature by virtue of education and/or training. Accordingly, the Guest Editorial subject should have special meaning or significance to these readers.

An important point to be emphasized is that Guest Editorials are not subject to any censorship, either expressed or implied, on our part. They are edited only for grammar, punctuation, sentence structure, etc., designed to help the author present his views as clearly and forcefully as possible. This, whether or not we agree with his views!

If in the course of editing we come across a statement that could prove detrimental to the author, his company, or to some other person or firm, we will so inform the author and suggest a remedial change. This change, is only a suggestion, however, and will not be made unless first approved by the author.

In essence, all editing is intended to best serve the author's interest.

Finally, the Guest Editorial can range from 750 to 1,500 words in length. When published, it is accompanied by the author's name, title, company affiliation, and photograph.

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We invite our readers to submit Guest Editorials for publication in the magazine. The only requirement is that we be advised in advance as to the subject and expected availability date of your manuscript. This information will help us resolve any conflicts in subjects, and also permit early publication of your Guest Editorial when it is received here in our offices.

Now, after this invitation, can we expect to hear from you?

Arthur M. Merrill
Editor

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Dibutyl Sebacate	0.935	7.9	Vinyl Resins, Cellulose Acetobutyrate, Synthetic Rubbers, Rubber Hydrochloride, Polystyrene, Polymethyl Methacrylate.	Low Temp. Flexibility, Excellent Aging Qualities, Non-toxic
Dimethyl Sebacate	0.986°	3.54 @ 30°C	Vinyl Resins, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate, Acrylic Resins.	High Solvency and Efficiency, Wide Compatibility
Dioctyl Sebacate	0.913	17.4	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility, Low Volatility, Good Electricals
Dicapryl Phthalate	0.972	55	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Highly Compatible, Low Volatility, Excellent Viscosity and Stability
Diisodecyl Phthalate	0.965	65	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Cellulose Nitrate, Cellulose Acetobutyrate, Chlorinated Rubbers.	Low Volatility, Good Electricals
Dioctyl Phthalate	0.983	57	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Highly Compatible, Good Flexibility
Isooctyldecyl Phthalate	0.973	68	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Improved Flexibility, Permanence, Good Electricals
Dioctyl Adipate	0.924	21	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility
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®Harflex 330	1.081	2270 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Synthetic Rubbers, Nitrocellulose, Cellulose Acetobutyrate.	Non-Migratory, Permanence, Highly Compatible
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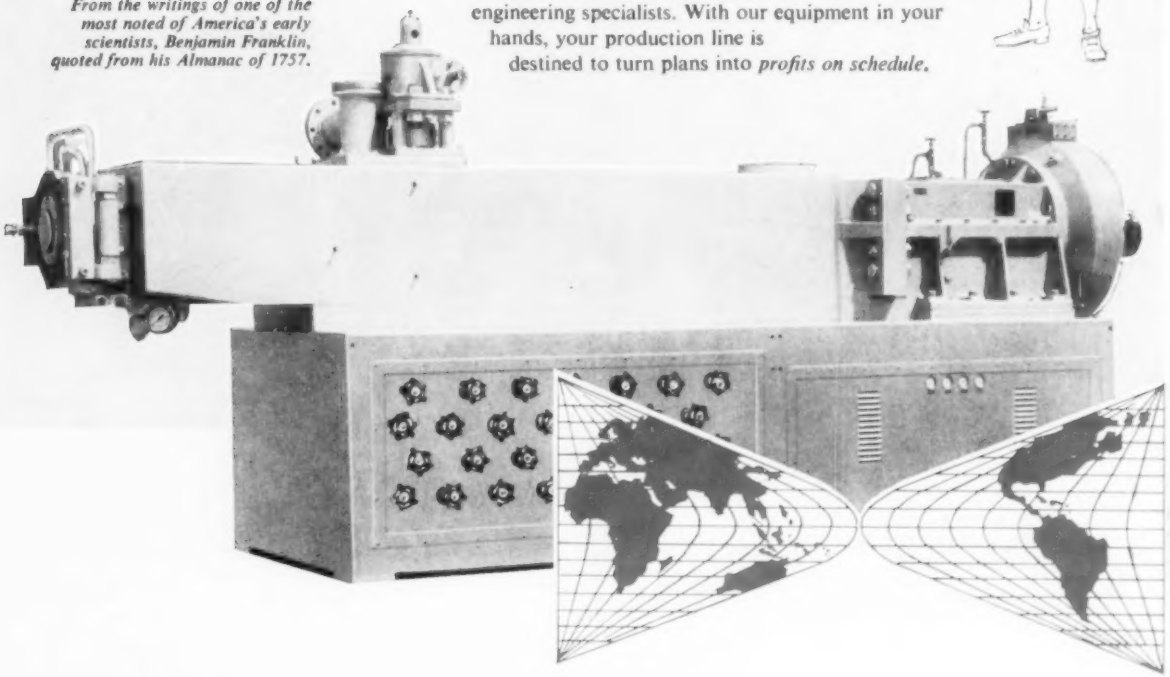

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PLASTICS
THE MAGAZINE OF APPLIED ENGINEERING
TECHNOLOGY

Post-molding operations on acetal resin

A comprehensive discussion of methods for machining and joining molded Delrin.

R. I. MILLER*

Machining, joining, and surface finishing are post-molding operations used in the production of plastic parts to obtain reduced costs, greater design flexibility, and improved appearance. For example, orifices may be drilled into carburetor parts or undercuts machined after molding to reduce costs through mold simplification. Joining of mating parts by welding or mechanical assembly make it possible to develop new plastic applications. Such items as housings, aerosol bottles, toys, lenses, valves, and floats are but a few of these new parts that are assembled after molding. Painting and metallizing are being used widely in the automotive and appliance industries to improve appearance and/or achieve greater styling latitude.

Delrin# acetal resin is well suited to a variety of post-molding operations because of its combination of mechanical properties. Typical properties of this resin are shown in Table 1. A strong, durable material, it is stiff, yet resilient; and possesses dimensional stability in combination with resistance to deformation, impact, wear, and fatigue. There is good retention of these properties when exposed to high temperatures in the presence of high humidity or practically all solvents.

Machining

Acetal resin can be machined on standard machine shop equipment by sawing, milling, turning, drilling, reaming, shaping, threading, and tapping. It is easier to perform these operations on this material by using hand tools than on the most machinable brass or aluminum alloys.

It is seldom necessary to use cutting oils, water, or other cutting aids except in the common wet-band sanding operation where water feed is normally used. Machinability is excellent at slow speed-fast feed and slow feed-fast speed using standard brass cutting tools. In most cases, standard chip breakers on tools perform adequately. Rods, discs, or plaques should be annealed to reduce internal stresses before machining. (The annealing procedure is discussed under stabilization of dimensions.)

Acetal resin may be used efficiently in automatic machining operations. In one test on a screw machine, acetal rod stock was introduced immediately following a production run on brass. The part shown in Figure 1 was machined to the required dimensions in 50% of the cutting time required for brass.

Table 2 summarizes the many machining operations that may be performed on acetal resin, and lists recommended tools, speeds, and coolant use.

R. Lewis Miller was born in Mexico, Mo., in 1926. He attended the University of Missouri, receiving a B.S. in Marketing in 1949 and a B.S. in Mechanical Engineering in 1950. Following his graduation, he went with E. I. du Pont de Nemours & Co., working in the Research & Development Division of the company's Polychemicals Dept. from 1950-1954. He transferred to the Department's Sales Division in 1954 and has been there since as Sales Technologist in the Technical Service Laboratory. He is a member of S.P.E.

Mr. & Mrs. Miller have two children, and make their home in Wilmington, Del.

* Sales Technologist, Polychemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.
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Table 1. Average Typical Properties of Delrin

	500 Series	100 Series
Elongation, %: At —68° F.	13	38
At 77°	15	75
At 158° F.	330	450
Impact strength, Izod, ft. lbs./in.:		
At —40° F.	1.2	1.8
At 77° F.	1.4	2.3
Tensile strength & yield point, psi.:		
At —68° F.	14,700	
At 77° F.	10,000	
At 158° F.	7,500	
Compressive strength at 1% deformation, psi.	5,200	
Compressive stress at 10% deformation, psi.	18,000	
Deformation with 2,000 psi. load at 122° F., %	0.5	
Flexural modulus, psi.: At 77° F.	415,000	
At 170° F.	190,000	
At 250° F.	90,000	
Flexural strength, psi.	14,100	
Shear strength, psi.	9,510	
Heat distortion temperature, ° F.:		
At 264 psi. loading	212	
At 66 psi. loading	338	
Water absorption, % at 24 hrs. immersion	0.12	
Specific gravity	1.425	
Rockwell hardness	M94, R120	
Melting point, crystalline, ° F.	347	
Flow temperature, ° F.	363	
Modulus of rigidity, psi.	178,000	
Dielectric strength, short-time, volts/mil	500	
Flammability, inches/minute	1.1	

Stabilization of Dimensions

By virtue of its combination of high heat-distortion temperature (338° F. at 66 psi.), low moisture absorption and low creep, acetal resin has excellent dimensional stability. Like many plastics and metals, however, parts sometimes are subject to internal stresses which are influenced in magnitude by molding conditions and the geometry of the part. The gradual release of these stresses (called environmental shrinkage), can result in dimensional changes which are particularly pronounced at elevated temperatures.

Such changes in dimensions can be reduced greatly by the use of a hot injection mold or by annealing after molding. Annealing will give maximum dimensional stability to molded parts. Either of these procedures will produce parts with good dimensional stability. The amount of environmental shrinkage which can occur with parts of acetal resin on prolonged exposure at various temperatures is given in Table 3. By referring to this Table, the designer can estimate the magnitude of environmental shrinkage that may occur, and determine whether or not a part should be annealed.

Annealing of Delrin should be carried out in the absence of air, preferably by immersion in a suitable annealing oil. The oil should be stable at the annealing temperature, should not attack Delrin, or give off noxious vapors. Refined mineral oil Primol D** or Nujol*** has been found to be satisfactory in this respect. Uniflo## lubricating oil also has been used successfully for the annealing treatment. In the case of stock having thin sections (under ½-inch), the annealing treatment will produce pieces of low internal stress and good dimensional stability. Although the annealing treatment for sections over ½-inch thick reduces internal stresses, some residual stresses may remain within the material.

** Primol D is the registered trademark of Esso Standard Oil Co. New York, N. Y.
*** Nujol is the registered trademark of Plough, Inc., Memphis, Tenn.
Uniflo is the registered trademark of Standard Oil of New Jersey, New York, N. Y.

Table 2. Machining Operations on Acetal Resin

Operation	Machines	Cutting Tools	Cutting Feed	Cutting Speed	Coolant Use	Remarks
Sawing	Standard	Std. 14 T.P.I., Slight Set	Medium	100-/300 fpm.	All speeds	Coolant improves finish of cut.
Drilling	Standard	Std. twist drills 159°	Medium	150 rpm. for ½" drill	At medium & high speeds	On-size holes drilled without coolant.
Turning	Standard	Std. cutters, single-fluted end mills	0.002-0.005"	690-840 fpm.	At high speeds	Depth of cut, 0.016-0.200". Support long lengths.
Milling	Standard	Std. cutters, single-fluted end mills	Similar to brass		Not required	———
Shaping	Standard	Standard	Similar to brass	Maximum	Not required	———
Reaming	Standard	Expansion type preferred	Medium	Similar to brass	At medium & high speeds	———
Threading & Tapping	Standard	Standard	Similar to brass		At medium & high speeds	Coolant facilitates cutting to dimensions.
Blanking & Punching	Standard	Standard	———	———	Not required	Primarily for stock less than 1/16" thick.
Filing & Sanding	Standard	Std. files, abrasive paper, & discs	———	———	Wet sanding	Finish will vary with type of file.
Finishing	Standard	6-12" D. muslin pumice & w-p compound	———	1,000-2,000 rpm.	Not required	Use light pressure & rotate parts.

air feed unit for spindle travel, and a timer for controlling the spindle stroke. Appropriate chucks for holding the parts and means for rapid ejection of the welded part are also necessary. Further refinement would be directed toward automatic handling of the parts in and out of the chucks.

Acetal resin requires a contact pressure at the joint of approximately 400 psi., and an average peripheral velocity of 20 feet per second. Higher pressures and speeds may be used when faster cycles are desired. Rapid stopping is required to prevent shearing of the fast setting melt. A braked motor or quick release

for welding Delrin is approximately 30 pounds of spindle for each square inch of weld area. The moment of inertia and/or the speed may be adjusted to bring the system into balance. Advantages of the inertia technique over the other methods are shorter cycles, excellent reproducibility of weld, minimum flash, simplified equipment, and close control over axial dimension of assembled part.

Possible spin welding applications for Delrin include fuel filter housings, fasteners, push-pull knobs, speedometer casing fittings, check valve caps, carburetor parts, air cylinders, and aerosol bottles.

Table 3. Environmental Shrinkage of Acetal Resin Due to Stress Relaxation*

	Environmental Temp., ° F.	Shrinkage, Mils/Inch
Routine molding—samples annealed at 320° F. for 15 minutes	— 40 to 170	<0.5
	170 to 212	1.5
	212 to 248	2.5
Molded at mold temperature of 250° F.—no annealing	— 40 to 170	<0.5
	180	1
	200	2.5
	212	4
Routine molding in cold mold (100-150° F.)—no annealing treatment	— 40 to 125	1
	125 to 150	1.5
	150 to 175	3

* Shrinkage values based on measurements of pieces made at room temperature after exposure as indicated. Test pieces consisted of soap dish, gear, sphere, dumbbell tensile specimen, bars, fatigue bars, and discs.

Table 4. Annealing Procedure for Acetal Resin

Section Thickness, Inches	Temperature, ° F.	Time, Minutes	Cooling
0.2	320±3	10	Air-cool at room temperature in draft-free container.
0.4		15	
0.6		20	
0.8		25	
1.0		30	
Over 1.0	300±3	1 hr./inch	(Same as above)

Annealing times and temperatures for various average thicknesses of the acetal part are suggested in Table 4.

Machining to Close Dimensions

If a part is to be machined from a thick section (½-inch or more) of Delrin, the part should be machined symmetrically from the geometric center of the original piece. For example, if a 3/8-inch thick gear blank is to be cut from a ¾-inch thick disc of Delrin, the gear should be cut from the center of the original disc. This technique will minimize the possibility of warpage due to unbalanced stresses during machining.

In addition, if a part is to be made from a thick section of Delrin, and maximum dimensional stability is needed, it is suggested that the part be rough machined to within 3/32- to 1/8-inch of final dimensions, and then re-annealed. This will reduce any remaining internal stresses and still permit final machining. The part will then be low in residual stress and should retain its critical dimensions.

In all machining operations, the fine shavings, turnings, chips, etc., of Delrin, like those of wood, should be removed to reduce possible fire hazards. Also, fine Delrin dust from grinding or sanding operations should be handled like other materials which might create fire or explosive hazards.

Welding

Spin Welding

Spin welding is rapidly becoming a common joining technique for plastic parts having circular contacting surfaces. Aerosol bottles, reflectors, wheels, fuel filter housings, pipe fittings, dowels, balls, and many other containers and parts have used spin welding as an economical, production assembly technique. Briefly, spin welding consists of rotating one part against another to generate frictional heat. When a melt film has been developed from the friction, the motion is stopped and the weld is allowed to cure under pressure. The entire operation is fast, requiring only a few seconds. Acetal resin can be spin welded on fast cycles because of its sharp melting point and rapid setting rate. Standard machine-shop equipment such as drill presses and lathes may be modified for spin welding. Minimum requirements to convert a drill press would include an

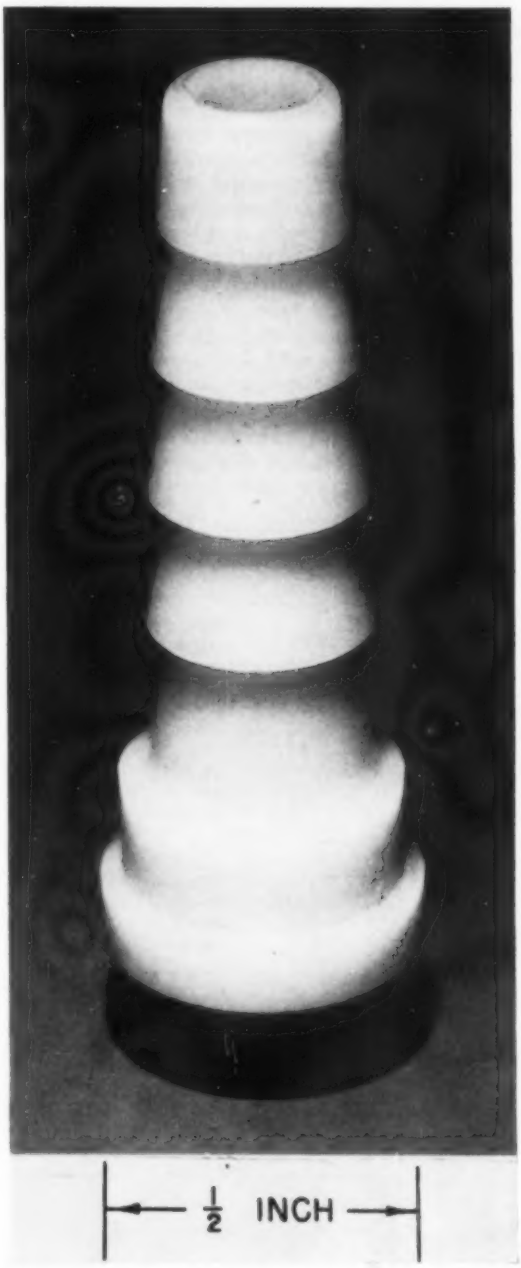

Fig. 1. Acetal resin fitting made by machining rod stock on automatic screw machine.

possible with nitrogen. The use of air also introduces the danger of oxidizing the acetal resin. When welding with air, the temperature should be 570° F. at a distance of ¼-inch from the nozzle tip of the welding gun.

Hot-Wire Welding

This welding method consists of clamping a wire between two pieces of the resin, and applying a voltage to the wire. The current generates enough heat to melt the adjacent surfaces and, as the pieces are pressed together, the material will flow around the wire and

shown in Figure 4. These represent the maximum interferences based on yield point and elastic modulus data. Where maximum joint strength is not required or where ease of fitting is more important, lesser interferences may be used. If a part is subjected to appreciable temperature fluctuations, the interference values in Figure 4 must be modified to account for differences in thermal expansion of the acetal and steel.

Snap Fittings

Two parts of acetal resin can be assembled and

air feed unit for spindle travel, and a timer for controlling the spindle stroke. Appropriate chucks for holding the parts and means for rapid ejection of the welded part are also necessary. Further refinement would be directed toward automatic handling of the parts in and out of the chucks.

Acetal resin requires a contact pressure at the joint of approximately 400 psi., and an average peripheral velocity of 20 feet per second. Higher pressures and speeds may be used when faster cycles are desired. Rapid stopping is required to prevent shearing of the fast setting melt. A braked motor or quick release device often is used. Unlike many other thermoplastics, acetal resin when spin welded forms a bead of melt (flash) at the joint which can be stripped off readily without need for subsequent machining.

Another technique for spin welding is the inertia method where the two parts, one spinning rapidly, are brought together suddenly under high pressure. An adjustable slip clutch is used to release the drive, and the spinning spindle is brought to a stop almost instantaneously by the friction in the joint. The spindle energy is dissipated into the joint, where sufficient melt is developed to form the weld.

The same technique can be used in reverse by allowing a movable, stationary chuck to accelerate to the speed of the powered spindle. The important element in both examples is to build adequate mass or resistance into the system so that the energy developed is sufficient to form the weld. Although exact energy balances have not been determined for this technique, a starting point for welding Delrin is approximately 30 pounds of spindle for each square inch of weld area. The moment of inertia and/or the speed may be adjusted to bring the system into balance. Advantages of the inertia technique over the other methods are shorter cycles, excellent reproducibility of weld, minimum flash, simplified equipment, and close control over axial dimension of assembled part.

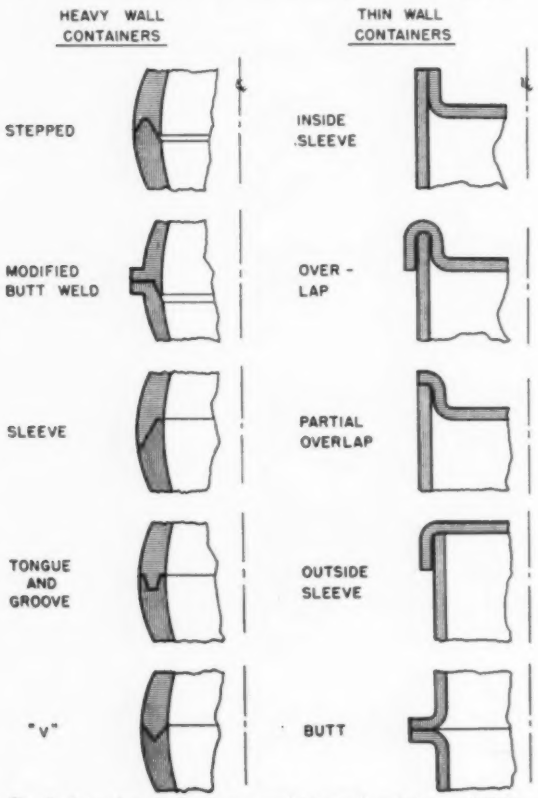

Fig. 2. Joint designs for heavy- and thin-wall containers of Delrin.

Possible spin welding applications for Delrin include fuel filter housings, fasteners, push-pull knobs, speedometer casing fittings, check valve caps, carburetor parts, air cylinders, and aerosol bottles.

Suggested joint designs for containers of Delrin are shown in Figure 2. Additional information on spin welding thermoplastics may be found in (1).*

Hot-Plate Welding

The two mating faces to be joined are first held against a heated metal surface to melt the surface layer of polymer. Parts then are held together, allowing them to fuse while the polymer cools. The temperature of the metal-heating unit should be between 445° and 555° F., with the optimum temperature being dependent on heating time, part size, and part geometry. For welding large areas, 10-15 minutes at 445° F. should be used; while 30 seconds at 500° F. is satisfactory for welding small areas. A strength of 8,000 psi. (80% of base resin strength) has been obtained with this technique.

It is extremely important not to put too much pressure on the melted resin. This is important both when melting the resin against the metal surface, and when joining the two surfaces. The pressure should be just enough to assure contact (less than one psi.). Flash (molten resin) spreading more than 1/16-inch from the edge during heating or joining indicates excessive pressure. Where hot plates are employed for melting the resin, an aluminum heating plate with a thermostatic switch is recommended because it maintains a uniform temperature throughout. Brass heating surfaces have a harmful effect on the melted resin.

When the weld is less than 1/4-inch thick, the surfaces can be joined by simply pressing them together lightly. When joining sections of greater thickness, the surfaces should be sheared across each other to eliminate any entrapped air which can reduce the tensile strength of welds from a normal 8,000 psi. to 6,500-7,500 psi. Joints involving small areas will set in 30 seconds and be ready for use in five minutes, while larger welds may take an hour or more to set and be ready for use.

Hot-Gas Welding

The pieces being welded may be aligned rigidly in fixtures. For very large welds, this has a distinct advantage—it is easier to move the welding gun than it is to move the part. The two main disadvantages of this welding technique are the time required, especially for multiple passes, and the high degree of skill required by the operator.

For best welding results, a 3/64-inch diameter welding rod made of the polymer is used with hot nitrogen at 630° F. Air can be used in place of nitrogen, although stronger welds (7,500 psi.) and faster operation are

* Numbers in parentheses refer to Bibliography at end of article.

possible with nitrogen. The use of air also introduces the danger of oxidizing the acetal resin. When welding with air, the temperature should be 570° F. at a distance of ¼-inch from the nozzle tip of the welding gun.

Hot-Wire Welding

This welding method consists of clamping a wire between two pieces of the resin, and applying a voltage to the wire. The current generates enough heat to melt the adjacent surfaces and, as the pieces are pressed together, the material will flow around the wire and form a weld. This method is simple, rapid, applicable to complex designs, and forms no flash.

The shear strength of welds made by this method has been approximately 750 lbs. per inch of embedded #20 wire. By increasing the length and/or the number of the wires used, the joint can be strengthened even further. The necessary equipment for this method is inexpensive. In most cases, it will be desirable to mold the parts with a retaining groove to position the wire used in the weld.

Induction welding, discussed in detail in (1), is another technique for welding acetal resin.

Mechanical Assembly

Press or Interference Fitting

This is one of the commonest and simplest fastening techniques. When applied properly, it provides rapid and inexpensive assembly of production-line parts. It is applicable to similar or dissimilar materials, and eliminates the need for a third joining member (such as cement, metal insert, etc.) in the finished joint.

Excellent creep resistance and high strength at elevated temperatures make possible strong press-fit joints of acetal resin. Experimental data indicate that at stress levels up to 5,000 psi., the initial relaxation of stress soon ceases. This assures high retention of strength in a press-fitted joint. The joint strength is relatively unaffected by temperature changes, and such joints are effective up to 250-300° F. Figure 3 illustrates the force at room temperature required to remove a ¼-inch rod from an acetal sleeve assembled with a 0.009-inch diametral interference fit after various exposure times at 200° F. Even after heating at this temperature for 1,000 hours (to accelerate stress relaxation), the removal force only decreased from an initial value of 400 pounds to an equilibrium value of more than 250 pounds, thus demonstrating good strength retention. In a practical example of a press-fit assembly for attaching a knob to a crank handle with a 10-mil interference on a 0.352-inch O.D. by 1.0-inch long shaft, the initial loads required to remove the knob ranged from 410 to 540 pounds.

Press fits of acetal to metals or other materials can be employed successfully, but may be limited by the environmental temperature range. This results from differences in coefficients of thermal expansion of the two materials. It can, in turn, result in loosening of the press-fit, overstressing the material, and/or complete loss of interference.

Calculated interference limits at room temperature for press-fitted shafts and hubs of Delrin and steel are shown in Figure 4. These represent the maximum interferences based on yield point and elastic modulus data. Where maximum joint strength is not required or where ease of fitting is more important, lesser interferences may be used. If a part is subjected to appreciable temperature fluctuations, the interference values in Figure 4 must be modified to account for differences in thermal expansion of the acetal and steel.

Snap Fittings

Two parts of acetal resin can be assembled and held securely by snap fitting them together. In general, a molded or machined undercut is used on one part, while the mating one has a lip to engage the undercut and retain the unit. Since acetal resin is one of the stiffest of engineering thermoplastics, relatively strong joints are possible with this fastening technique.

The necessary interference will depend on the geometry and thickness of the parts, as well as the environmental temperatures and the service life required. Specifically, the magnitude of interference is dependent on the yield point of the resin at assembly conditions.

Figure 4 also may be used to approximate the amount of interference that can be used in a snap-fit assembly. The principal advantage of a snap-fit assembly over a press fit is that pull-out strength does not diminish with time since the parts once assembled are in a relatively unstressed condition. Snap fits, on the other hand, cannot be relied upon for sealing, and the degree of undercut possible is limited by ejection difficulties during molding.

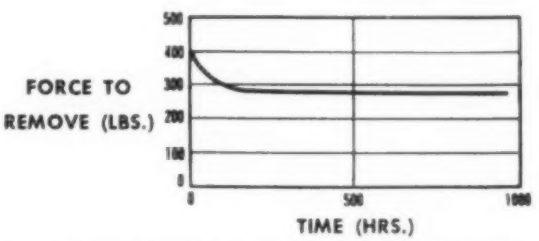

Fig. 3. Stress relaxation of acetal resin interference fit. Fit exposed to 200° F. temperature, and force to remove was measured at room temperature.

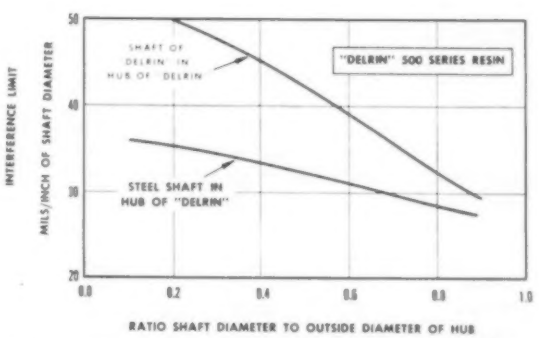

Fig. 4. Interference limits for press-fitting Delrin and steel.

Table 5. Pull-Out Strength of Self-Tapping Screw* in Delrin Acetal Resin

Engaged Thread Length, Inches	Pull-Out Strength, Lbs.
1/4	600
3/8	1,000
1/2	1,800

* 3/16-inch diameter F10-24 screw.

Table 6. Recommended Hole Sizes for Standard Self-Tapping Screws

Screw Size	Threads per inch	Nominal Pitch Diameter, In.	Nearest Drill Size
2	56	0.0734	49
	64	0.0750	48
3	48	0.0844	44
	56	0.0864	44
4	40	0.0946	41
	48	0.0974	41
5	40	0.1076	36
	44	0.1090	7/64
6	32	0.1163	32
	40	0.1206	31
8	32	0.1423	9/64
	36	0.1447	27
10	24	0.1612	20
	32	0.1683	19
12	24	0.1872	3/16
	28	0.1912	11
1/4	20	0.2157	3
	28	0.2252	2
5/16	18	0.2743	I
	24	0.2837	9/32
3/8	16	0.3321	Q
	24	0.3462	11/32

Self-Tapping Screws

Self-tapping screws are rapid, efficient, and inexpensive fasteners for acetal parts. The excellent machining properties of acetal resin, combined with high strength and creep resistance, permit easy insertion and permanent retention of self-tapping screws. As a result of these properties, Delrin has a high strip-out: drive ratio which permits its use with power-driven tools. Such items as refrigerator door handles, instrument clusters, appliance housings, and numerous other components can be assembled on a production-line basis using self-tapping screws.

Thread cutting screws, such as ASA Type F or T, should be used. The thread forming-type screw has reduced strip strength and produces excessive strain in the boss. Fine threads are recommended for maximum vibration resistance and strip strength. Figure 5 shows the effect of pitch and time on back-out torque. The fine pitch, $^{10}/_{32}$ thread exhibits better resistance to loosening.

Optimum boss size as related to screw diameter for maximum strip strength can be seen in Figure 6. Note that ratios of boss: screw diameters greater than 2.5 show no gain in strip strength of the screw. Actually, the gain begins to fall off rapidly after a ratio of 2.0:1. Pull-out strength may be approximated by the shear strength of a cylinder of Delrin the same diameter of the screw and the axial length of thread engagement. The depth of the hole should be 1.5 to 2.5 times the screw diameter, plus the tapered length of the screw end. Table 5 shows values of pull out strength for several thread engagements.

Axial load or retention (compressive load under screw head) decreases with time in direct proportion to the decrease in apparent modulus. Figure 7 shows most of the stress relaxation occurring in the first 100 hours. Optimum hole diameter for self-tapping screws in acetal parts is essentially the pitch diameter of the screw. Smaller holes increase drive torque with little or no gain in strip torque, and increase chances of splitting the boss. Larger holes reduce drive torque, strip torque, and vibration resistance. Table 6 gives the recommended hole sizes for a variety of self-tapping screws.

Riveting, another mechanical fastening technique, has been discussed previously in (1).

Nailing & Flaring

Strong nailed joints are possible because of the high compressive strength of Delrin. A No. 17 wire nail has a holding power of 100-115 pounds when driven into ¼-inch thick Delrin. Nailing of Delrin is best done with sharply pointed nails and a powerful rapid blow like that of an automatic nailer.

Another practical joining method is hot flaring. This technique is similar to riveting in that the shaft pin is preheated with hot air (400-500° F.), inserted through the parts, and headed over with a peening tool.

Cementing

Cementing acetal resin is very difficult because of its extreme solvent resistance. However, several commercial adhesives can be used to make low-strength bonds of acetal to acetal. Procedures have been developed using adhesives that can be cured at room temperature or by baking at elevated temperatures. Details of the procedures may be found in (2).

Lap joint strengths in shear of 300-500 psi. can be obtained with the recommended adhesives. The solvents and aqueous resistance of the bonded joint, in general, will be as good as that of the adhesive.

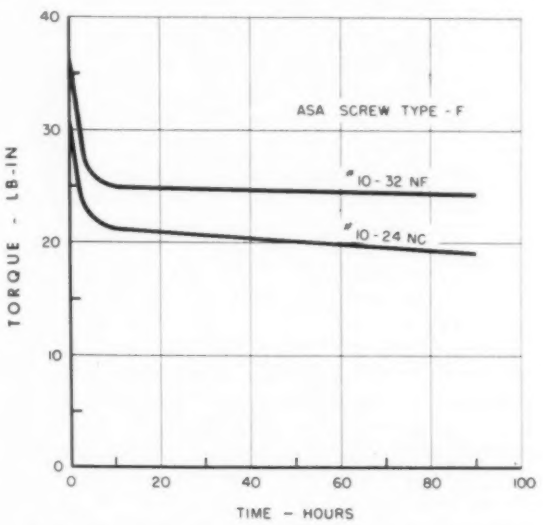

Fig. 5. Back-out torque of self-tapping screw in Delrin acetal resin.

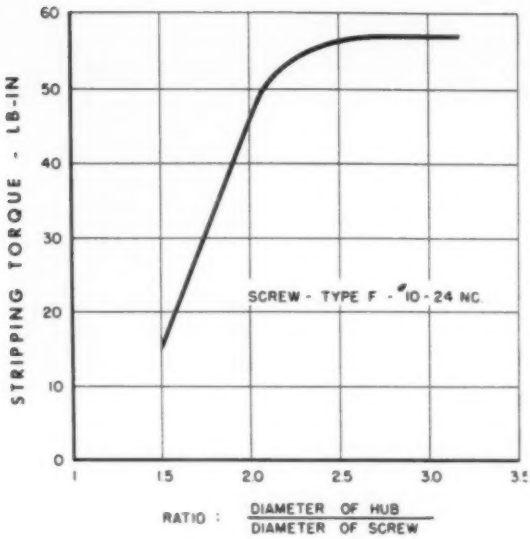

Fig. 6. Effect of boss diameter on stripping torque of self-tapping screw in Delrin acetal resin.

Other Methods

Techniques for painting and metallizing have been developed for use with acetal resin. Details of this procedure may be obtained from (2).

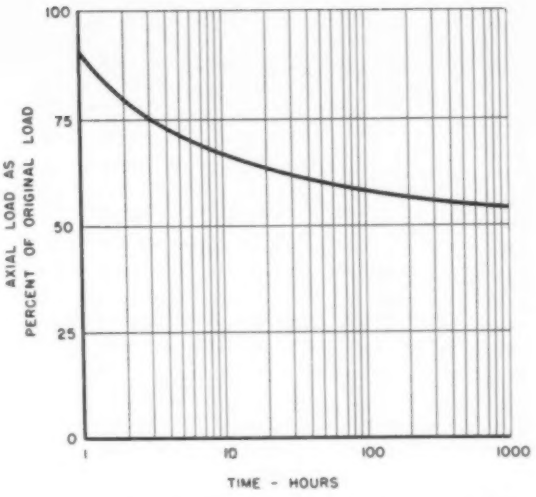

Fig. 7. Effect of time on axial load of self-tapping screw in Delrin.

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—THE END

Extruded diffuser helps solve museum lighting problem

Sectional fixtures shielded by Extru-Lite in Guggenheim Museum.

Frank Lloyd Wright's singular contribution to the New York City skyline, the Solomon R. Guggenheim Museum at 88th Street and Fifth Avenue, may well be the most widely discussed structure of the century. This novel museum, with its spiralling ramp galleries, posed a unique set of display problems to the director, James Johnson Sweeney. One of these problems was the lighting.

Wright had designed the building to capture sunlight. Ribboned skylights around the perimeter of the spiral ramp admitted the sun's rays in full force behind the paintings. The daylight glare transmitted and the sharp light and dark contrasts created by the skylights would not only have been annoying to the eyes, but would have tended to distort colors, thus preventing optimum viewing. Mr. Sweeney, with Alfred Binder, illuminating engineer and designer for American Lighting Corp. of New Jersey, and A. E. Alper, electrical contractor of Daylight Electrical Construction Corp., are the men responsible for the final interior lighting.

Three-lamp fluorescent luminaires, conforming to the U-shaped gallery, have been hung flush with the ceiling. Light is beamed at a 40-degree angle toward the paintings. Comprised of five or six sections locked together, the luminaires appear to be built-in units. The ratio of illumination of the three lamps is approximately 2:1 of cool white to warm white light. A plastics shield, Extru-Lite, diffuses and controls the light to achieve the desired brightness.

Conceived and manufactured by Rotuba Extruders, Inc., Brooklyn, N. Y., Extru-Lite has 9,000 prisms per square foot and weighs approximately 0.6 pound per square foot in ⅛-inch thicknesses. The shields are extruded from Rohm & Haas' Plexiglas acrylic resin.

Effects of secondary plasticizers on processing of vinyls—II

The second section of a two-part article showing how a vinyl processor can achieve required properties in specific applications

P. D. SHARPE*

Volatility tests are performed under very accelerated conditions. The SPI volatility test (ASTM D1023-55) was used for determining volatile losses which could be anticipated with the secondary plasticizers under investigation. Ten-mil films of the plastics were embedded in activated charcoal in a closed container and placed in a circulating-air oven for 24 hours at 158° F. The samples were conditioned, reweighed, and percent plasticizer loss calculated. These results are shown in Table 3.

The data indicate volatile loss to be correlated with the amount of secondary plasticizer in the system. The more relatively-volatile secondary plasticizer used, the higher will be the loss. Losses with the high-viscosity aromatic hydrocarbons (Plasticizers B and C) are not too severe. Volatile losses with chlorinated paraffins (Plasticizer J) are of the same order as with DOP. Losses of approximately 4-6% can be anticipated with the alkyl-aryl hydrocarbon type (Plasticizer D), when used as 15-25% replacements for DOP, under accelerated conditions.

It should be recognized that the results shown for volatile loss are obtained under accelerated methods. Attempts have been made to correlate such results with anticipated life-expectancy of the plastics. The accelerated loss shown with the very-aromatic hydrocarbon plasticizer (I) is almost eight times that of the ester (DOP) under the same conditions. However, the actual service life of a plastic composition containing this aromatic secondary was found to be more than four years before noticeable changes were evident. Secondary hydrocarbons of the special petroleum fraction type (A) which are suggested as 25% replacements for esters, show volatile losses about three times higher than the ester, DOP. Yet, the actual service lives of some of the plastics containing such secondary products have been found to be better than six years. The significance, therefore, of these accelerated aging tests is questionable, and should be used only as a comparative guide in predicting actual performance.

The heat-history for processing vinyls is not necessarily severe. Although considerable fuming may be experienced in processing with hydrocarbon plasticizers, this is not necessarily indicative of large volatile loss. The petroleum hydrocarbons have a rather broad distillation range. The initial 5% of this boiling range may contain some low-boiling components, and the excessive fuming usually is due to these "light ends."

Tests have been conducted with the very highly aromatic, volatile hydrocarbons which were processed in vinyls for various periods of time at 300° F. A mere 4% loss of plasticizer was encountered after 60 minutes at 300° F. In compounding this amount can be compensated by the use of a slightly-higher total plasticizer content.

All factors must be considered in volatility; the end-use of the plastic compound, its thickness, the percent total plasticizer used, and the severity of actual service conditions. Some compromise may be necessary with a secondary plasticizer in the interest of cost savings.

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Table 3. Volatility of Secondary Plasticizers After 24 Hours at 158° F. (50 phr Total Plasticizer).

DOP Primary Plasticizer, %	Secondary Plasticizer %	Secondary Plasticizer Code	Weight Loss, %
100	—	—	1.5
85	15	A	4.0
80	20	A	4.4
75	25	A	5.3
85	15	B	2.6
80	20	B	3.0
75	25	B	3.7
85	15	C	2.7
80	20	C	4.1
75	25	C	4.6
85	15	D	5.4
80	20	D	6.5
75	25	D	6.8
85	15	E	4.7
80	20	E	5.4
75	25	E	6.1
85	15	F	5.3
80	20	F	5.4
75	25	F	6.5
85	15	G	5.3
80	20	G	6.0
75	25	G	6.8
75	25	H	4.6
50	50	H	4.9
30	70	H	5.7
75	25	I	5.5
50	50	I	7.4
25	75	I	10.3
0	100	I	12.6
85	15	J	1.7
80	20	J	1.7
75	25	J	1.7

Table 4. Low-Temperature Flexibility with Secondary Hydrocarbon Plasticizers (50 phr Total Plasticizer).

DOP Primary Plasticizer, %	Secondary Plasticizer %	Secondary Plasticizer Code	Rating* at 0° F.	Rating* at —20° F.	Rating* at —40° F.
100	—	—	P	P	P
75	25	A	P	P	F
75	25	B	F		
75	25	C	F		
75	25	D	P	F	
75	25	E	P	P	F
75	25	F	P	P	F
75	25	G	P	P	P
75	25	H	P	F	
75	25	I	P	F	
50	20	I	P	F	
25	75	I	F		
0	100	I	F		
75	25	J	P	P	P

* P—Pass; F—Fail

Low-Temperature Flexibility

Plasticized vinyl compounds become stiffer and usually brittle as the temperature is lowered. The low-temperature flexibility of a vinyl composition is closely associated with plasticizer viscosity. There is also a rough correlation between the freezing point of a polymer (temperature at which the internal movement of the polymer chains becomes too low for it to respond as an elastomer) and the amount of plasticizer required to develop good low-temperature properties. The higher the freezing point of the pure resin, the more plasticizer necessary. Since polyvinyl chloride has a freezing point of 158° F., considerable plasticizer of the proper type must be used to improve the low-temperature properties of the resin.

Plasticizers most suitable for low-temperature properties should have intermediate compatibility with the resin. If a plasticizer is too compatible (in the sense of forming very strong plasticizer attachments), the plasticizer molecules become too firmly attached. This restricts elastomeric movements of the chains owing to the interlocking effect of the plasticizer bonds. Something between these extremes of compatibility is most desirable, wherein the plasticizers form only weak attachments and the chains can move easily under stress from one set of plasticizer contacts to another.

Many secondary hydrocarbon plasticizers are ideally suited for improving the low-temperature properties of polyvinyl chloride resins. They are of low viscosity, have intermediate compatibility with the resin, and have low freeze points.

In order to examine the possibility of using these secondary plasticizers in a plasticizer system and improving the low-temperature flexibility of an ester-plasticized vinyl, compounds were prepared using the secondaries as 25% replacements for DOP. The highly aromatic plasticizer (Plasticizer I) was investigated throughout its complete range of compatibility. Tests were conducted with the samples according to the low-temperature flexibility method (ASTM D736-54T). Results are shown in Table 4.

The viscous aromatic hydrocarbon products (Plasticizers B and C) are unsuitable for low-temperature requirements. They make the compound too rigid as temperature decreases, and exhibit poor low-temperature characteristics. Likewise, the highly aromatic hydrocarbon secondary product (Plasticizer I) detracts from the low-temperature properties of the vinyl. Alkyl-aryl hydrocarbons, such as Plasticizer D, are slightly better than the aromatics and detract less from low-temperature brittleness. The special petroleum fraction (Plasticizer A) and partially hydrogenated alkyl-aryls, such as Plasticizer E, are almost as good as straight DOP in a vinyl compound subjected to low-temperature flexibility. Alkylated naphthalenes (G) and hydrogenated terphenyls (F) do not detract from the low-temperature performance of a vinyl compound, as compared with a DOP-plasticized one.

A blend of secondary hydrocarbon plasticizer and phthalate ester is not suggested to improve the low-temperature properties of a plastic composition. The usual technique is to use such secondary materials as part of the plasticizer system to reduce costs. For example, a low-temperature plasticizer system may consist of equal parts of a phthalate ester in combination with a sebacate, adipate, or azelate. About 25% of the low-temperature plasticizer can be replaced with a low-viscosity product such as a special petroleum fraction (Plasticizer A) or a hydrogenated alkyl-aryl hydrocarbon (Plasticizer D) to maintain the required

Table 5. Light-Stability of Secondary Plasticizers in Vinyl Resins (50 phr Total Plasticizer).

% DOP Primary Plasticizer	Secondary Plasticizer %	Secondary Plasticizer Code	Light-Stability Rating* after Fade-Ometer Exposure, Hrs. 0	24	48	72	96	120
100	—	—	0	0	0	0	0	0
85	15	A	0	0	0	0	0	1
80	20	A	0	0	0	0	1	1
75	25	A	0	0	0	0	1	1
85	15	B	5	6				
80	20	B	5	6				
75	25	B	5	6				
85	15	C	5	6				
80	20	C	5	6				
75	25	C	5	6				
85	15	D	0	0	0	0	0	0
80	20	D	0	0	0	0	0	0
75	25	D	0	0	0	0	0	1
85	15	E	0	1	2	2	2	2
80	20	E	0	1	2	2	2	2
75	25	E	0	1	2	2	2	2
85	15	F	0	0	0	0	0	0
80	20	F	0	0	0	0	0	1
75	25	F	0	0	0	0	0	1
85	15	G	0	2	2	2	3	3
80	20	G	0	3	3	3	3	3
75	25	G	0	3	3	3	3	3
75	25	H	4	5	6			
50	50	H	4	5	6			
30	70	H	5	5	6			
75	25	I	3	6				
50	50	I	4	6				
25	75	I	4	6				
0	100	I	4	6				
85	15	J	0	0	0	0	1	1
80	20	J	0	0	0	0	0	0
75	25	J	0	0	0	0	0	0

* Ratings: 0—Practically colorless
1—Faint yellow
2—Light yellow
4—Faint amber
5—Amber
6—Brown

properties at reduced costs. Chlorinated paraffins also are of value for this purpose.

Light Stability

The light-stability of a vinyl plastic composition containing secondary plasticizers will vary with the amount of this type of plasticizer. Table 5 shows the results obtained on exposure of 10-mil films to ultraviolet light in an Atlas single arc Fadeometer for up to 120 hours. Samples were rated arbitrarily from 0-6, according to degree of discoloration.

Several of the secondary plasticizers imparted a definite color to the plastic composition. This was not considered in its rating; only the change from the original. The results show the resistance of vinyl compounds to color change by ultraviolet light to be a function of the plasticizer. Samples using secondary petroleum hydrocarbons (Plasticizers B and C) generally are less light-stable than those with an all-primary ester such as DOP. Chlorinated paraffins (J), alkyl-aryl hydrocarbons (E), and special petroleum fractions (A) have fair resistance. The more aromatic secondary plasticizers exhibit poor light resistance due to the presence of polycyclic compounds present which are unstable to ultraviolet light. The use of the highly aromatic secondary plasticizers (H and I) are suggested only where color stability is not an important factor.

Fillers and proper stabilization will reduce the degree of discoloration with secondary products. Lead stabilizers, particularly of the silica gel-complex type are suggested for the more aromatic secondary plasticizers, if they can be tolerated in the ultimate compound. The light-colored, less-aromatic secondary products are stabilized rather effectively by the use of barium-cadmium compounds in combination with a zinc chelator and an epoxy.

Migration

Plasticizer migration and staining are of importance when the plastic comes in contact with other surfaces and marring would be a problem. This is caused by diffusion of the plasticizer into the surface-coating with which it comes in contact. The tendency of a plasticizer to migrate depends upon contact time with the surface, temperature conditions, and relative solubility of the plasticizer in the plastic and the contact surface. Viscosity of the plasticizer also plays an important

Table 6. Physical Properties of General-Purpose Insulation Vinyl Compounds Containing Secondary Plasticizers (50 phr Total Plasticizer).

% DOP	Secondary Plasticizer %	Code	Original Properties at 70° F. Modulus, at 100%, Psi.	Tensile, Psi.	Ult. Elongation, %	Hardness, Shore A (10")	% Retention after Oven Aging Seven Days at 158° C. Tensile	Elong.
100	—	—	1,725	2,610	300	89	94	83
75	25	A	2,245	2,810	250	94	103	88
75	25	B	2,125	2,770	265	93	100	95
75	25	C	1,975	2,695	300	92	101	85
75	25	D	2,020	2,575	255	94	103	90
75	25	E	1,960	2,750	290	90	98	86
75	25	F	1,910	2,665	300	90	102	86
75	25	G	1,945	2,660	290	92	102	86
75	25	H	1,960	2,675	290	92	105	90
75	25	I	2,000	2,895	300	89	99	83
75	25	J	2,060	2,695	295	92	100	94

Table 7. Electrical Properties of General-Purpose Vinyl Compounds Containing Secondary Plasticizers (50 phr Total Plasticizer).

% DOP	Secondary Plasticizer %	Code	Power Factor, D	Dielectric Control, K	Power Loss, DxK
100	—	—	0.1020	4.014	0.40943
75	25	A	0.0788	3.935	0.31007
75	25	B	0.0711	3.753	0.26683
75	25	C	0.0675	3.683	0.24867
75	25	D	0.0818	3.990	0.32638
75	25	E	0.0675	3.245	0.21903
75	25	F	0.0663	3.468	0.22989
75	25	G	0.0659	3.343	0.22030
75	25	H	0.0664	3.923	0.27031
75	25	I	0.0731	3.923	0.27804
75	25	J	0.0780	3.760	0.29328

role in non-migration, since the rate of movement of plasticizer across the interface is a direct function of its viscosity. For non-migration, resinous and polymeric plasticizers are preferred.

To determine its effects in the plasticized vinyl stocks under investigation, samples were placed in direct contact with a panel coated with nitrocellulose lacquer. A load of one pound per square inch was placed on the set-up and maintained at 70° F. and 50% relative humidity. Samples were observed at intervals to 30 days for softening or marring of the coating.

The results show the sample using DOP alone to have a slight effect on marring of the surface. None of the other samples showed any lacquer lifting, and all contained a certain portion of secondary plasticizer. The secondary hydrocarbons, therefore, provide a safety factor from migration at ordinary room temperatures.

However, as we go down in viscosity with some of the secondary hydrocarbon plasticizers, temperature will play a part in hastening any migration tendencies. The aromatic, low-viscosity hydrocarbon plasticizers are satisfactory up to service temperatures of 125° F., even as the major portion of a plasticizer system. The special petroleum fractions are not recommended at this temperature for continued service. Small amounts of basic lead silicate, ethyl cellulose, or silica gel-reaction products in the plastic formulation sometimes will inhibit migration of secondary, low-viscosity plasticizers.

Odor

The odor of a plasticizer is difficult to classify, since all have some odor. The preference of one odor over another is a matter of opinion. The majority of secondary hydrocarbon plasticizers have a characteristic odor which, although not objectionable, is associated with petroleum products.

The bulk odor of these products generally is more prominent than the residual odor in the finished article for two reasons: (1). A small amount of "light ends" which may predominate in odor will volatize in the finishing and forming operation; and (2). The amount of secondary plasticizer is only a small portion of the total plasticizer in a compound so that the effect of its odor is minimized. It is only when the more compatible, highly-aromatic secondary plasticizers are used as a major portion of the plasticizer system that the odor of the secondary product will be prevalent.

In these instances, masking the odor is possible through use of high-boiling deodorants. There are a considerable number of these on the market, many designed to mask the odor of a particular-type product. Such materials do a rather effective job when used in minute amounts, based on the percent secondary product being used.

Color

Secondary hydrocarbon plasticizers for vinyls vary in color from almost water-white to pale straw for the special petroleum fractions and alkyl-aryl hydrocarbons, to pale yellow for the aromatics, and to deep golden-brown or greenish-brown for the heavy aromatic hydrocarbon plasticizers. The color of the plasticizer will be imparted to the final product, in proportion to the amount used.

In most instances, however, these colors are not intense, and can be masked in opaque compounds by the usual techniques of using a white base to produce any desired shade of plastic. The pale yellow straw color of some secondary products, which may be im-

Table 8. Heat-Stability Ratings* of Secondary Plasticizers for Vinyl Resins (50 phr Total Plasticizer).

% DOP	Secondary Plasticizer, %	Code	0	20	40	60	80	100	120	140	160	180
100	—	—	0	1	1	1	2	2	2	3	3	-
75	25	A	0	1	1	1	2	2	2	3	4	4
75	25	B	6	7								
75	25	C	5	7								
75	25	D	0	1	1	2	2	3	3	3	4	5
75	25	E	0	1	1	2	2	2	3	3	3	4
75	25	F	0	1	1	2	2	2	3	3	3	4
75	25	G	0	0	1	1	1	2	2	2	2	3
75	25	H	3	4	4	5	5	6	6	6	7	7
75	25	I	2	2	2	2	3	3	3	4	4	5
50	50	I	2	2	2	3	3	3	3	4	5	5
25	75	I	3	4	5	6	6	7				
75	25	J	1	2	2	3	3	3	4	4	5	5

* Ratings: 0—Colorless
1—Faint yellow
2—Light yellow
3—yellow
4—Faint amber
5—Amber
6—Dark amber
7—Brown

parted to clear, transparent compounds, can be corrected by incorporating very small amounts of blue- or purple-colored dyes to have a blueing effect. This is often resorted to, even with water-white plasticizers when pronounced crystal clarity is desired.

Electrical Properties

Electrical properties of a vinyl are of prime importance for the many kinds of insulation and dielectric materials. Most pure chemical plasticizers give good electrical properties. It is necessary that they be free from electrolytes, water, and other impurities.

Many secondary hydrocarbon plasticizers are also suitable for improving the electrical properties of vinyl resins. Aromatic petroleum hydrocarbons and special, low-viscosity petroleum fractions give excellent electrical properties to polyvinyl chloride plastics. The low-cost, viscous, aromatic hydrocarbon products—such as Plasticizers B and C—contain small amounts of water and are not recommended where maximum electrical properties are required. However, the end-use and the required specifications of the finished product will determine whether these types can be used in an electrical compound.

The various secondary plasticizers under investigation were evaluated as 25% replacements for the ester plasticizer, DOP, in a general-purpose vinyl insulation formulation, as shown below:

	Parts
Electrical-Grade PVC Resin	100
Dioctyl Phthalate	37.5
Secondary plasticizer	12.5
#33 Clay	10
Tribase	7
DS-207	1

Tensile properties were obtained with the compounds both before and after aging for 168 hours at 158° F. The results are shown in Table 6.

Electrical properties (viz., power factor, dielectric constant, and power loss) were obtained by means of a "Q" meter, Type 260-A, 50KC-50-MC, made by Boonton Radio Corp. These results are shown in Table 7.

The insulation compound tested is a typical 60° C.-type. Underwriters' Specifications call for this type of vinyl insulation to maintain 65% of its original properties after accelerated aging. All the compounds tested meet these requirements. The higher retention of tensile strength of compounds containing secondary plasticizers after aging is indicative of some stiffening due to volatility, as compared with the all-DOP compound. Percent retention of elongations was as good as or better than the ester compound in all cases.

Power loss of an insulation compound should be low. The data show secondary plasticizers to improve this property for vinyl insulation, as compared with an all-ester compound. The alkyl-aryl hydrocarbons and alkylated naphthalene plasticizer show very low power loss. Aromatic hydrocarbon plasticizers also demonstrate good electrical properties.

These data show the applicability of secondary plasticizers in 60° C. vinyl insulation. Other Underwriters' Specification insulation (80° and 105° C.) is subjected to more severe heat aging requirements which probably could not be met with secondary hydrocarbon plasticizers due to the loss of properties on aging. The use of these low-cost extenders should be investigated in blends to determine their feasibility for the more severe requirements.

Heat Stability

Heating of plasticized polyvinyl chloride compositions for long periods at high temperature results in a darkening of the resin. This discoloration may not always be detrimental, but is a warning of more serious degradation coincident with the liberation of acid, and loss of plasticizer and plastic properties which eventually follow discoloration.

For the investigation of the plastic compounds under test, one-inch diameter plugs were placed on aluminum panels and heated in an oven at 160° C. Samples were removed every 20 minutes and the color change recorded by means of an arbitrary numerical rating. Table 8 shows results which emphasize intensity more

Table 9. Tensile Properties of Secondary Plasticizers for Vinyl Resins (50 phr Total Plasticizer).

% DOP	Secondary Plasticizer %	Code	Modulus at 100%, Psi	Tensile Strength, Psi.	Ult. Elongation, %	Shore A Hardness, 10-Sec.
100	—	—	1,510	2,610	320	82
85	15	A	1,785	2,690	315	85
50	20	A	1,790	2,640	310	86
75	25	A	1,840	2,730	305	88
85	15	B	1,720	2,690	330	85
80	20	B	1,910	2,830	310	87
75	25	B	1,995	2,730	305	88
85	15	C	1,775	2,800	320	84
80	20	C	1,840	2,740	310	85
75	25	C	1,910	2,875	300	86
85	15	D	1,665	2,595	300	85
80	20	D	1,680	2,495	300	87
75	25	D	1,760	2,585	280	87
85	15	E	1,650	2,665	325	83
80	20	E	1,730	2,755	315	84
75	25	E	1,735	2,705	300	85
85	15	F	1,695	2,770	325	83
80	20	F	1,720	2,765	305	84
75	25	F	1,860	2,825	290	85
85	15	G	1,730	2,715	330	83
80	20	G	1,755	2,825	320	84
75	25	G	1,750	2,705	310	85
75	25	H	1,880	2,850	315	85
50	50	H	2,190	2,845	300	89
30	70	H	2,470	2,960	260	94
75	25	I	1,735	2,865	320	83
50	50	I	1,905	2,955	305	84
25	75	I	2,140	2,850	255	85
0	100	I	2,345	2,845	230	94
85	15	J	1,730	2,650	330	85
80	20	J	1,840	2,770	320	86
75	25	J	1,840	2,705	310	87

than discoloration. They indicate the tendency of the plasticized composition to discolor during processing.

The viscous aromatic hydrocarbons and the more aromatic hydrocarbon plasticizers result in greater color degradation of the vinyl composition, as compared with the ester-plasticized compound. This is due to the presence of certain components in the aromatics which are neither heat- nor light-stable.

The alkyl-aryl hydrocarbon (Plasticizer D) and the special petroleum fraction (Plasticizer A) are less heat-stable than DOP. However, they do not contribute too greatly to discoloration of the vinyl compound. The alkylated naphthalene (Plasticizer G) shows good heat-stability—about comparable to the ester-plasticized sample. Chlorinated paraffins (Plasticizer J) are about comparable to the special petroleum fraction with respect to color degradation due to heat.

The degradation of polyvinyl chloride resins under the influence of heat is a complex phenomenon. Use of secondary plasticizers of certain types can contribute to this color change. Vinyl resin compounds, if sufficiently and accurately stabilized can be improved in resistance to heat, even with secondary hydrocarbon plasticizers. The use of fillers also will aid in overcoming the limited heat-stability of vinyl compounds with certain secondary hydrocarbon products.

Flammability

The flame resistance of vinyls is an important consideration for some applications. Secondary plasticizers of the chlorinated paraffin type (J) are valuable for such purposes, as are certain of the aromatic petroleum plasticizers. Darby has stated ". . . Sovaloid C, a petroleum hydrocarbon fraction, showed surprising flame retardance. Tricresyl phosphate, cresyl diphenyl phosphate, and alkyl diaryl phosphate are quite flame retardant." A combination of a highly aromatic hydrocarbon plasticizer with a phosphate would be a good blend for improving the flame resistance of vinyl compositions.

Tensile Properties

The efficiency of a plasticizer is and should be associated with cost. Many primary plasticizers are more expensive than the vinyl resin. Therefore, it is generally desirable to use the minimum quantity to obtain desired physical properties. For plasticizers which are considerably cheaper than the resin, it is economically advantageous to use as much as possible of them without affecting quality.

Secondary plasticizers are less efficient than primary products in most cases. Their general effects on a

vinyl compound can be anticipated by replacing incremental amounts of an ester with a secondary plasticizer. They include an increase in 100% stress or lower efficiency; an increase in hardness of the compound; and a reduction in ultimate elongation. Tensile strength may increase or decrease.

These effects are demonstrated in Table 9 for 15%, 20% and 25% replacements of DOP with the secondary materials under investigation. Hardening and stiffening of the plastic compound are most pronounced with the viscous aromatic plasticizers and the highly-aromatic secondary product, especially as larger amounts of the latter are used for the ester. Elongation also suffers considerably as compared to an all-ester compound when large amounts of highly-aromatic secondary plasticizers are used.

The substitution of one plasticizer for another, either in total or in part, requires that the replacement plasticizer be used in an amount which maintains the original flexibility or hardness of the product. Physical properties are a direct function of hardness or flexibility. Comparative data on compounds, whether such data be on processing, physical properties, or aging qualities, are useful only if such data are based on compounds having the same flexibility or hardness.

This reasoning has been the basis for the arbitrary establishment of efficiency factors for plasticizers. These factors are a means whereby a compounder can calculate the concentration of a plasticizer system needed to obtain a room-temperature flexibility or hardness in a desired range. Efficiency factors actually are values assigned for a plasticizer concentration required for a given 100% modulus or for a given hardness.

By using the data shown in Table 9, a compounder can determine the proper blend of a secondary plasticizer and DOP necessary to obtain properties comparable to an all-ester compound.

There are certain considerations which must be recognized in interpreting the data. An ideal compound consisting only of resin, plasticizer, and stabilizer was used for evaluation. DOP was used as the control plasticizer, because of its widespread use in industry. No fillers were used, since they affect the plasticizer: resin ratio. In establishing a commercial compound, it would be necessary to determine the efficiency factor for the filler used (i.e., the filler would absorb a certain amount of plasticizer and this would have to be compensated for in the compound).

Using such data it is possible to obtain the tensile properties of a vinyl compound with a blend of plasticizers comparable to that of a single plasticizer. When secondary products are used, they require an increase in total plasticizer concentration. This is a common practice throughout the industry to take advantage of the cost savings possible with secondary materials. A savings of 2-3¢ on a pound volume basis is not unusual.

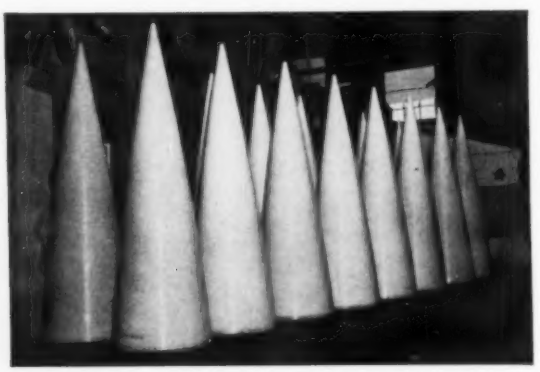
Conclusions

It is recognized that no one plasticizer can give all the necessary properties desired in a vinyl article. The usual practice is to use several plasticizers of various types to obtain the specific properties required.

Secondary hydrocarbon plasticizers no longer are curiosities. They have found a place in the industry, and have reduced costs with only a small sacrifice in quality. With proper use, they will go a good job; with proper education, they will do a better job.

—THE END

Plastic radome noses



These reinforced polyester nose cones protect the Bomarc Missile's guidance mechanism during flight.

The dunce caps above are ready to be attached to the Air Force's Bomarc ground-to-air missile. Each reinforced polyester nose cone will protect a missile's guidance mechanism during supersonic flight, as well as transmit radar beams which indicate the target.

The cones are formed by Brunswick-Balke-Collender Co. by a technique called "filament winding." Glass strands impregnated with Vibrin 135, a polyester resin produced by Naugatuck Chemical division, U. S. Rubber Co., are concentrically wound about a stainless steel form by a high-speed winding machine. Thermocouples are attached, and the assembly is cured in a special oven. Subsequent grinding of the radome surface to a uniform electrical thickness insures even radar transparency.

Vibrin 135 was selected because it has an almost constant radar transparency curve over a wide temperature range. Furthermore, it will maintain strength after comparatively long exposure at temperatures over 500° F.

—THE END

Guest editorial

The nature of an elastomer and a proposed definition

J. P. McMAHON*

The vast increase in the number of new types of plastics, rubbers, and so called rubber-like materials during the past decade has promoted considerable ambiguity and conjecture among research workers, patent attorneys, and lexicographers as to what can and what cannot be classified as an elastomer.

The word "elastomer" denotes a solid polymer or copolymer having elasticity. It may be organic or inorganic, but it must be a polymer whose elasticity is a function of its chemical structure and not a result of mere physical plasticizing or mechanical configuration (such as weaving, perforating, or foaming). The elasticity must be inherent to the molecular constitution of the polymer or copolymer.

The word "elasticity" means obvious extensibility and/or compressibility under stress, with immediate recovery of a polymer to approximately the original dimensions when the stress is removed. The extensibility must be obvious to the naked eye. Some types of hard rubber, for example, have all the properties of elastomers except obvious extensibility and/or compressibility; therefore, they would not qualify as elastomers. Their elasticity, although present to some degree, is not apparent.

The recovery must be rapid when the stress is relieved and complete enough so that the object appears to have the same dimensions. Because of hysteresis losses, differences in magnitude, and duration of stress, etc., recovery may be only approximate, but it must occur immediately on removal of stress without apparent permanent deformation.

The extensibility, I believe, should be of such a nature as to be apparent on application of only moderate stress. Some materials such as the highly cross-linked, flexible polymers or semi-hard rubbers do demonstrate some measure of elasticity under high stress, but they are not elastomers and, therefore, should be excluded from this classification.

The elasticity of an elastomer should be in evidence at ordinary (room) temperatures. I do not know of any polymer that would acquire elasticity at lower than ordinary temperatures if it did not have this property to begin with. If such materials exist or are discovered, they will require a separate classification. However, there are many polymers that acquire greater elasticity on heating than they have at room temperature, but most, if not all, have enough inherent elasticity before heating to qualify as elastomers, and I would suggest that a material shall not be classified as an elastomer unless it has elasticity at room temperature. The question of the effect of temperature on elasticity is confused by the fact that many polymers acquire extensibility on heating, but we must remember that extensibility or compressibility is not elasticity.

With these points in view, I wish to propose the following definition of an elastomer:

"An elastomer is a solid organic or inorganic polymer or copolymer having inherent and obvious extensibility and/or compressibility at room temperature on application of moderate stress; accompanied by immediate and approximate recovery to its original and undeformed dimensions when the stress has been removed." END

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Presenting creep data on reinforced plastics

Two methods for the presentation of stress-rupture data

E. VAN ANTWERP*

High strength and low weight are the properties of glass-reinforced plastics that have made them attractive to designers. Until recently, their use has been limited by two factors; failure to retain this strength at elevated temperatures, and non-uniformity of mechanical properties from batch-to-batch. Now, plastics that retain their strength have been developed, and improved manufacturing techniques have reduced the spread in their mechanical properties. Before these materials can be used extensively, however, the time-temperature effect on them must be evaluated. This is best done by "creep-rupture" testing.

As the test temperature increases, the effect of small load increments increases rapidly, and the number of reinforcing fibers becomes increasingly critical. Since both of these factors are difficult to control, considerable scatter is observed in the test results. This scatter requires extensive testing to establish proper design curves, resulting in high testing costs. Some method of presenting test data which would place a proper emphasis on all the tests could reduce these testing costs. This article is the result of a search for such a method.

Method of the creep-rupture data on reinforced plastics are reported as curves of stress versus rupture time or stress versus log rupture time, reported in the same manner as data for tests run on metals. This is the conventional manner for reporting rupture data, but it has two weaknesses: (1). variability in individual curve-drawing techniques can affect the final results; and (2). when scatter occurs, duplication of tests is necessary to validate points on the curve. These weaknesses are intensified when the tests are made on reinforced plastics, where (for reasons mentioned above) the inherent scatter in test results is large, and the small slope of the curve makes the curve position critical.

The Data Problem

To determine what others were doing to solve this problem, a literature survey was made covering the major part of work done on creep and tension testing of plastics. Emphasis was placed on the manner in which test data were presented. Because little work has been done on reinforced plastics, data on other plastics were included in the survey.

The material survey may be divided into three groups. The first group consists of work dealing only with tensile properties. The second group (1).* consists of work done on both tensile and creep properties. The third group (1,2,3,4) includes tensile, creep, and rupture data. Nearly every investigator stresses the difficulty encountered in obtaining valid test results. The susceptibility of most plastic materials to environmental changes and difficulty in preparing suitable samples affect the test results greatly.

All of the investigators in the first two groups reported their data in the conventional manner; stress-strain curves were reported for the tensile test, and individual strain versus time curves for the creep tests. A plot of stress versus creep rate usually was included.

Most of the reports in the third group also were made in the conventional manner. Some mention of the large number of tests required to obtain the conventional plots was included in the report. Two different approaches were found in this group. Sampson and Vondracek (5) have suggested a method for plotting a stress versus rupture life curve for any single temperature. This method makes use of all creep rupture test values and the tensile values. S. Goldfein (6) has suggested that the results of all creep rupture tests, regardless of temperature, may be plotted on a single curve of stress versus a parameter which combined rupture life and temperature. From this curve, extrapolated values of rupture life may be determined, provided that test conditions do not make the material unstable.

These methods were applied to several sets of available data to check their validity. These data appear in Tables 1, 2, and 3. In Figure 1, the Sampson-Vondracek plots (5) are compared to the conventional stress versus time curves. Figures 2, 3, and 4 illustrate

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* Numbers in parentheses refer to Bibliography at end of article.

Table 1. Comparison of Three Methods for Presenting Data

Laminate	Testing Temp., ° F.	Testing Time, Hrs.	Stress, Psi. Determined by Conventional Method	Stress, Psi. Determined by S-V Method	Stress, Psi. Determined by Goldfein Method	% Deviation from Conventional S-V Method	% Deviation from Conventional Goldfein Method
Polyester/Glass-P	80	1	29,800	33,800	30,000	+13.4	+0.7
		10	29,400	32,200	29,600	+9.5	+0.7
		100	29,200	30,300	28,300	+3.8	−3.1
		500	28,900	28,800	28,100	−1.0	−2.8
	200	1	28,000	29,200	27,400	+4.29	−2.1
		10	27,700	28,800	27,100	+3.98	−2.2
		100	27,300	28,200	27,300	+3.3	0.0
		500	27,000	27,900	27,000	+3.3	0.0
Epoxy/Glass	80	40	41,100	43,600	41,200	+6.1	+0.23
		200	40,100	41,600	40,300	+3.7	+0.50
		500	39,400	40,300	39,800	+2.3	+1.0
Polyester/Glass-S	80	1	43,000	45,300	41,500	+5.6	−3.5
		10	40,300	41,400	39,500	+2.7	−2.0
		100	38,000	38,000	37,500	0.0	−1.3
		500	36,300	35,700	36,300	−1.7	0.0

Table 2. Typical Stress-Rupture Data

Laminate	Temperature, ° F.	Rupture Time, Hrs.	Stress, Psi.
Polyester/Glass-P	80	3.8	30,000
		3.8	29,500
		194.6	29,000
		1,077.0	29,000
	200	1.7	28,000
		23.7	27,500
		1,178.0	27,000
Polyester/Glass-S	80	60.7	39,000
		116.6	37,500
		720.0	36,000
		955.0	31,500
Epoxy-Glass (8)	73	1	43,000
		10	42,000
		100	41,000
		1,000	39,000
		10,000	37,500
		20,000	37,200

Table 3. Typical Tensile Strength Data

Laminate	Tensile Strength, Psi.
Polyester/Glass-P	39,100
Polyester/Glass-S	53,800
Epoxy/Glass (8)	54,100

the Goldfein plots for the same data.

The method suggested by Sampson and Vondracek is an empirical relation developed to provide a means for comparing the stress-rupture properties of glass-reinforced laminates. It was developed for use with tests having a maximum life of 200 hours, and utilizes a straight-line relation on a double-log plot, thus providing easy extrapolation. Two points were plotted to locate the straight line; the first point being the average tensile strength of the material plotted at 0.0165 hour, and the second being the arithmetical average of all the rupture-life values plotted at the arithmetical average of all of the stresses. This was repeated for each test temperature involved.

While the line plotted by this method seldom coincides exactly with the one arrived at by conventional means, it does give good agreement in the 100-500 hour portion of the plot. An example of this is shown in Table 1. It is of interest to note that attempts to apply this method to published data on rupture tests performed on metals have been unsuccessful.

From the data currently available, it appears that the main advantage to be gained from use of this method lies in its ability to provide a satisfactory approximation of the stress versus rupture life curve in the 100-500 hour range, where considerable scatter is

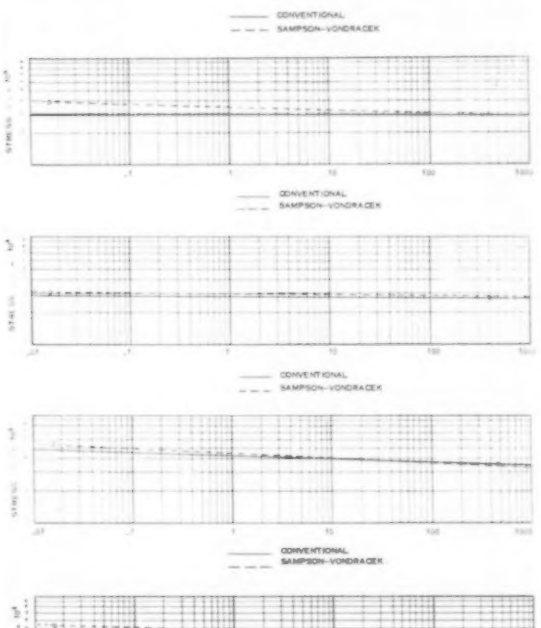

Fig. 1. Comparison of data for stress versus rupture life of polyester/glass-P at 80° F. (top); polyester/glass-P at 200° F. (second from top); polyester/glass-S at 80° F. (second from bottom); and epoxy/glass at 73° F. (bottom).

Table 4 Stress-Rupture Data Obtained on Experimental Laminate

Test Number	Temperature, ° F.	Stress, Psi.	Rupture Life, Hrs.
1	75	39,000	0.1
2		38,500	0.1
3		35,000	0.1
4		34,000	0.33
5	500	13,000	184.9
6		13,000	76.8
7		13,500	155.0
8		14,000	41.5
9		14,000	0.5
10		14,000	29.8
11	75	28,000	129.5
12		30,000	7.1
13		27,000	571.0
14		31,000	1.4
15		32,000	0.43
16	0	40,000	0.1
17		40,000	1.0
18		40,000	1.6
19		35,000	2.2
20		30,000	73.0
21		36,000	64.3
22	—20	43,000	0.7
23		35,000	1.6
24		38,000	3.9
25		41,000	2.9
26		40,000	13.2
27		37,000	16.6
28		38,000	24.8
29		36,000	229.5

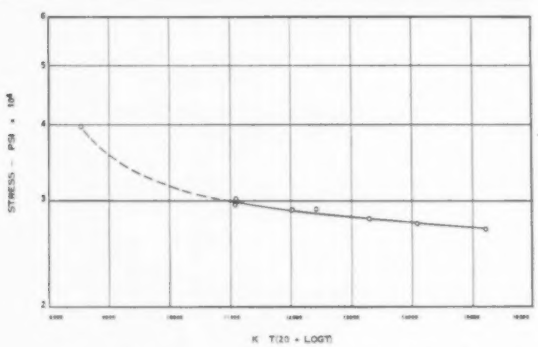

Fig. 2. Stress versus K value for polyester/glass-P.

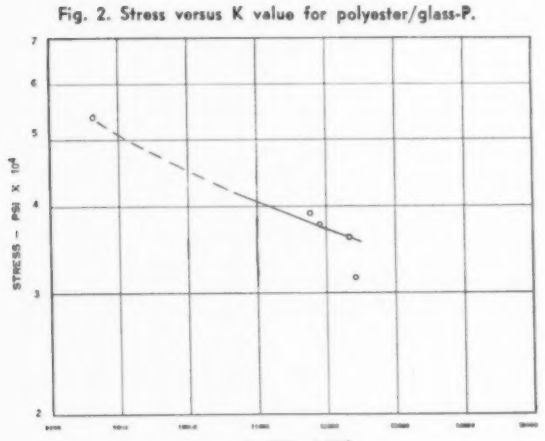

Fig. 3. Stress versus K value for polyester/glass-S.

encountered in testing. The method suggested by Mr. Goldfein involves application of the Larson-Miller parameter (7) to the testing of glass-reinforced laminates. The Larson-Miller parameter is represented by the formula:

$$K = T(20 + \log t)$$

where K = Larson-Miller parameter
T = Temperature in degrees Rankin
t = Rupture life of specimen in hours

A master curve of stress versus Larson-Miller parameter is plotted from tests made at one or several temperatures. Data to substantiate the plotting of the tensile strength at a value of 10^{-4} hours is presented by Mr. Goldfein (8), (9). The dotted portion of the curves in Figures 5, 6, and 7 illustrates the use of this time value for plotting tensile strength values. While the master curve will compensate for some scatter, it is not as effective as the Sampson-Vondracek method. Figure 5 illustrates the effect of scatter encountered in testing an epoxy glass laminate when all of the data is plotted using the Goldfein method.

The use of the Goldfein method appears to have two advantages; extrapolated values check well with actual test values, and intermediate temperatures need not be tested. However, the second advantage is offset somewhat by the need for better test points.

During the study of these two methods, several variations of the Sampson-Vondracek method were considered. The first involved the method for obtaining the point representing the rupture life data. Since the value obtained by arithmetically averaging the test data seldom fell on the conventional curve, it seemed desirable to obtain a value which was located on this curve. The logarithmic average was found to fall on the conventional curve, but the use of this value in plotting the data did not necessarily improve the agreement.

Examination of Figure 1 reveals that whenever the Sampson-Vondracek method was applied to existing data, the point representing the tensile data was always above the conventional curve. This would indicate that the time value assigned to this point was too large. Since Goldfein had presented evidence that 0.0001-hour was a representative value for these materials, it seemed logical to substitute this value for the 0.0165 hour specified. The use of this time value reduced the slope of the line so that it more nearly coincided with the conventional curve, and resulted in an appreciable reduction in the percent deviation from the conventional data. When this value is used on the data plotted in Figure 1, the deviation from the conventional stress is reduced from + 13.4 to + 9.1% at one hour; at 500 hours, the deviation changes from —1.0 to 0.3%. Since the slope is lower, the angle formed at the intersection of this curve with the conventional curve is smaller. This makes the agreement between the two methods better for the longer time values.

To illustrate the application of these methods, they have been applied to a set of data obtained on an experimental laminate. The data appears in Table 4.

As frequently happens when testing this type of material, difficulty was encountered in obtaining valid tests. The tests numbered 1-10 represent the result of

Table 5. Comparison of Four Method for Presenting Data Obtained on an Experimental Laminate

Temperature, ° F.	Time, Hours	Stress, PSI., Determined by Conventional Method	S-V Method	Modification A	Modification B	% Deviation from Conventional S-V	A	B
75	1	31,200	33,400	35,800	34,300	+3.8	+14.7	+9.9
	10	29,800	30,200	34,900	34,000	+1.3	+17.1	+14.1
	100	28,100	27,200	34,000	31,400	−3.3	+21.0	+11.8
	500	26,900	25,300	33,700	30,200	+6.0	+25.3	+12.3
500	1	14,000	14,000	13,900	13,950	0.0	−0.7	−0.4
	10	13,800	13,800	13,800	13,800	0.0	0.0	0.0
	100	13,600	13,600	13,650	13,600	0.0	+0.4	0.0
	500	13,300	13,300	13,400	13,300	0.0	+0.8	0.0
0	1	39,000	41,200	38,800	37,800	+5.6	−0.5	−3.1
	10	37,400	38,000	37,300	36,000	+1.6	−0.3	−3.7
	100	35,800	34,900	36,200	34,200	−2.5	+1.1	−4.5
	500	34,700	32,800	35,300	32,900	−5.5	+1.7	−5.3
−20	1	44,500	44,000	41,300	41,300	+8.6	+2.0	+2.0
	10	38,700	40,300	39,500	39,600	+4.1	+2.1	+2.3
	100	36,900	37,200	37,900	38,000	+0.8	+2.7	+3.0
	500	35,400	35,000	36,500	36,600	−1.7	*3.1	+3.4

the initial testing. Tests 1-4 are room-temperature tests; obviously no conventional curve can be drawn. By using the Sampson-Vondracek method, the curve appearing in Figure 5 was obtained. Subsequent testing, listed as tests numbers 11-15 in Table 4, resulted in the conventional curve appearing on the top curve of Figure 6.

The middle curve of Figure 6 contains the data appearing as tests numbers 5-10; the lower curve of Figure 6 contains data listed as tests numbers 16-20; and the upper curve of Figure 7 represents the data listed as tests numbers 21-29. In each case, the solid line represents the conventional curve and the dotted line represents the Sampson-Vondracek curve.

In each case, the results of modifying the Sampson-Vondracek method, as discussed above, was determined in the deviation from the calculated conventional curve. The comparison of these methods appears in Table 5. Examination of the data reveals that the use of the Sampson-Vondracek method on this stress-rupture data resulted in deviations of not more than 8.6% where rupture lives of between one and 500 hours were considered. It should be noted that with

(Continued on page 51)

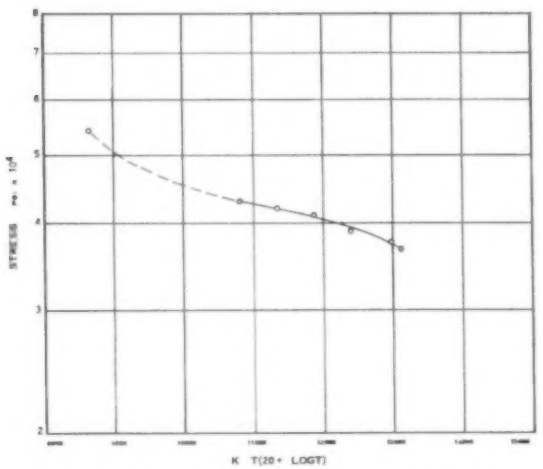

Fig. 4. Stress versus K value for epoxy/glass laminate.

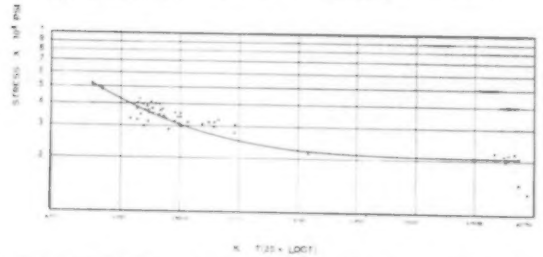

Fig. 5. Larson-Miller plot of stress versus K value for epoxy/glass laminate.

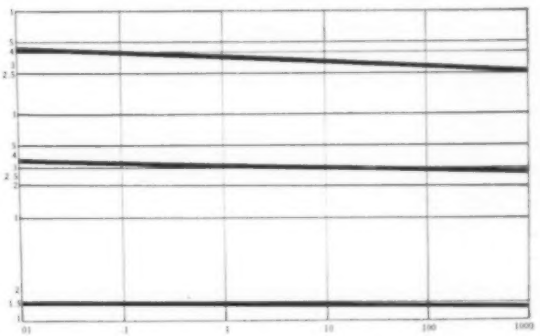

Fig. 6. Stress versus rupture life: Sampson-Vondracek curve at 75° F. (upper); experimental laminate at 75° F. (center); and experimental laminate at 500° F. (lower).

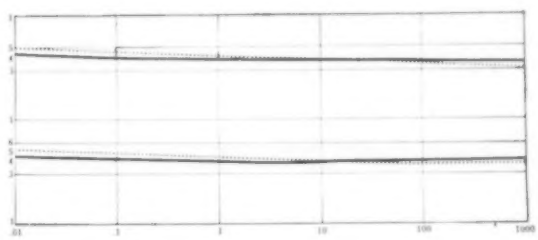

Fig. 7. Comparison of stress versus rupture life curves for an experimental laminate at 0° F. (upper) and −20° F. (lower).

ENGINEERING FORUM

Compression & transfer molding

Another look at molding pressures

Edited by: PAUL E. FINA*

During the past few months, the writer has had occasion to present several talks on thermosetting plastics to some large groups—both within the plastics field and in industry at large. During the ensuing question-and-answer period, the types of questions asked indicated interest of two types; molding techniques, and types of applications suitable for plastics. One of the salient questions usually asked pertained to the method of computing compression molding pressures. This article will be devoted to the presentation of the important basic factors affecting molding pressures, and the method most often employed in calculating substantial molding pressures. The author realizes that much has been written on this subject, and hopes that my more erudite readers will not be offended if "another look at molding pressures" is attempted. It must be noted that this article does not include discussion of transfer (plunger) molding.

Factors Affecting Molding Pressure Determination

Two values that must be derived separately are:

(a). The tonnage of molding pressure required for each horizontal square inch of area, based on the total depth of part (draw). This will be called *Basic Unit Pressure.*

(b). The total horizontal (projected) square inch area involved that is to be subjected to pressure. This will be called *Total Pressure Area.*

These two values, when multiplied together, give the final molding tonnage needed to produce a full molding. In other words, Basic Unit Pressure Times Total Pressure Area results in the total molding pressure required.

The Unit Pressure, as given in a data sheet, usually is expressed in pounds per square inch, and serves only as a general guide. The range denoted is wide because there are many factors which affect molding pressure. These variable factors include design of mold, vertical depth of part, distance of flow of material, volatile content, wall sections, duration of flow, plasticity of compound, type of filler, method of handling material, pre-heat conditions, temperature of mold, and press closing speed. Usually, a material supply engineer can estimate the correct Basic Unit Pressure if he is supplied with the proper information. It must be mentioned that fairly accurate Basic Unit Pressures are not derived quickly. Deliberate consideration is required. Even then, the final decision is of an empirical nature.

For most molded parts, the engineer can determine the "initial" molding pressure on the basis of flow or plasticity of molding compound, and add it to about one-quarter of this "initial" pressure for each additional inch of draw depth. Initial pressure is the pressure for the first inch of draw. Depth of draw is the total height of the part as it would stand in the mold. Pressures should be converted into tons to simplify the final computation (i.e., Basic Unit Pressure times Total Pressure Area).

INITIAL MOLDING PRESSURE. Soft flows or plasticity require approximately one-half of the pressure of hard flow. Distance of flow (duration of flow) is affected by mold temperature. At a certain temperature, duration of flow time is considered a "constant". If there are thin walls in any direction and the molding compound must be forced to flow through this restricted area, more pressure is required. Compounds having higher thermal conductivity (e.g., mineralized) require faster closing of the press. One way of accomplishing fast close is to utilize higher molding pressure. Preheated materials usually require less molding pressure, if they become tacky or pliable during pre-heat. Faults and remedies in molding will not be discussed in this article. To obtain actual initial molding pressure, the material supplier should be called in for information, and a molding-pressure evaluation should be made of the material chosen. Nothing can take the place of actual molding experience. Records should be kept on the basis of the variable factors previously mentioned.

* Dir. of Sales Engrng., The Fiberite Corp., Winona, Minnesota

Empirical Molding Pressure Chart* (A-Soft Flow, B-Hard Flow).

Resin	Filler	Compression Molded, Psi. (up to one-inch draw)** Unpreheated	Compression Molded, Psi. (up to one-inch draw)** Preheated	Transfer Molded** (Pre-heated) Psi. (up to one-inch runner length) 1/8-inch diameter gate	Transfer Molded** (Pre-heated) Psi. (up to one-inch runner length) 1/4-inch diameter gate
Phenolic	General-purpose or Flock	A 1,800-2,500 B 2,500-3,000	A 1,200-1,800 B 1,800-2,500	A 6,000- 8,000 B 10,000-15,000	A 4,000- 7,000 B 8,000-12,000
	Light Fabric	A 2,000-2,500 B 2,500-3,000	A 1,500-2,000 B 2,000-2,500	A 8,000-12,000 B 14,000-18,000	A 6,000-10,000 B 12,000-16,000
	Heavy Fabric	A 2,500-3,200 B 3,200-4,000	A 2,000-2,500 B 2,500-3,200	A 12,000-16,000 B 18,000-23,000	A 10,000-14,000 B 16,000-20,000
	Cord	A 2,500-3,200 B 3,200-4,000	A 2,000-3,200 B 2,500-3,200	A 14,000-18,000 B 18,000-22,000	A 12,000-16,000 B 16,000-20,000
	Fiberglass (One-Step)	A 1,800-2,500 B 2,500-4,000	A 1,200-1,800 B 2,000-3,000	A 8,000-15,000 B 15,000-20,000	A 6,000-14,000 B 12,000-18,000
	(Two-Step)	A 1,200-1,600 B 1,600-2,200	A 1,000-1,400 B 1,400-1,800	A 4,000- 6,000 B 6,000-12,000	A 3,600- 5,000 B 5,000- 8,000
	Asbestos	A 2,000-2,500 B 2,500-3,200	Not recommended Not recommended	A 8,000-12,000≠ B 14,000-18,000≠	A 6,000- 8,000≠ B 12,000-18,000≠
	Sisal or Nylon	A 1,300-2,000 B 2,000-2,500	A 1,000-1,500 B 1,500-2,200	A 5,000- 7,000 B 8,000-12,000	A 4,000- 6,000 B 6,000- 9,000
Melamine	Fabric	A 3,000-4,000 B 4,000-6,000	A 2,500-3,500 B 3,000-4,000	A 12,000-18,000 B 20,000-26,000	A 10,000-16,000 B 18,000-24,000

* Figures given are only a guide for standard molding compounds.
** For compression, use about one-quarter more pressure for each added inch of draw; for transfer (plunger) molding, use 15-20% more pressure for each added inch of runner.
≠ High-frequency preheat not recommended.

DEPTH OF DRAW. The additional pressure for draw usually is a simple calculation. The parting line or flash line, as planned, is the point from which to measure. For solid parts, bowls, or cone-like shapes, the bulk material or preforms could be so loaded or distributed as to preclude flowing during mold closing. This can effectively reduce the distance of flow (depth of draw). This method of reducing the required molding pressure is only a suggestion. For practical reasons, it has been found best to use the actual depth as the basis. As a section diminishes in thickness and it is evident that the material must be forced between narrow confines, more pressure is required. For sections less than ⅛-inch thick, 50% more pressure may be needed.

The total pressure area involved may be stated simply as any contact area under pressure. Include area of molded part, land area, pressure pad surface, etc., since all areas under contact are subject to pressure. This means that the available molding pressure will distribute itself.

To derive the total pressure area, carefully lay out the mold design in advance. Then, physically measure all proposed contact surfaces. The sum total is the total pressure area.

In conclusion, conservatism is suggested. If the tolerances are close and harder flows are expedient, borderline molding pressures will create critical molding conditions. It is better to be safe than sorry. Molding under very low pressures could mean unreliable results. Molding pressure calculation is an important part of every estimate. —THE END

Erratum

With all our rigid system of proofreading and checking that we strive to improve continually, our gremlins also keep evolving and, despite our system, occasionally succeed in slipping an error into the magazine. With the foregoing preface, we must admit that the article, "Stabilization of Vinyl Copolymer Resins," that was published in the April issue, pages 35-38, 42, showed the author's name on the Contents Page, p. 2, as G. A. Tanner instead of the actual author, D. G. Knowles. Luckily, Mr. Knowles' name appeared as the author on the first page of his article (p. 35). Our gremlins may be proud of their achievement, but we sincerely apologize for the error.

ENGINEERING FORUM

Injection molding

Venting of injection molds

Edited by: R. E. Hoehn*

The following is a special contribution received from E. P. Moslo, Pres., Moslo Machinery Co., Cleveland, Ohio.

The art of injection molding is old. The science of building molds is very well known, and we have innumerable mold makers in the United States today who make excellent production molds. They use the proper steels, proper finishes, and parts are machined to very exacting tolerances. However, the part of the mold that, in the writer's estimation, is most important, is most neglected in the average injection mold which goes into an injection molding machine. This is proper venting.

If a mold does not function well, the blame is put on the mold maker for making a bad mold or on the injection machine for not having the ability to fill the mold properly and on proper cycles. A common complaint is that the molder can only shoot a limited number of square inches of area in a given injection press because the clamp tonnage is not high enough. The other common excuse is that the machine does not plasticize enough. Neither of the above is true in most cases.

The writer has been in innumerable injection molding plants and when examining molds, finds only one in 50 or 100 are vented so that they will run with their best efficiency in production. It is well known that plastic will not flow through an opening up to 0.0015-inch in thickness. Innumerable molds are made where the mold maker, after finishing the mold, has put the assembled unit on a surface grinder and ground across the face of the cavities' openings 0.001 - to 0.0015-inch in depth and widths anywhere from ⅛- to 1¼-inch. He installs the mold into the molding machine and starts it up, and it will run fine for just a little while. However, after the mold has been in operation for a few hours, it becomes sluggish; cavities no longer fill unless temperatures on the injection cylinder are raised and injection pressures also are increased.

The majority of thermoplastics, when they are brought up to heat in an injection cylinder, carry a given amount of volatile material. This volatile material must escape through the venting system in the mold, and it does. However, the mold surfaces are much colder than the gasses and the volatiles. Under the circumstances, condensation takes place and, in a little while, a build-up of these volatiles in the vents completely shuts them off. On raising heats and pressures after the vents become plugged, it is possible to release the gasses trapped in the cavity by the simple process of stretching the tie bars slightly. The mold will pop open, the gasses will escape, and the mold will close again. In many cases, there is no sign of flash whatsoever. However, in a machine with limited clamping capacity, flash will occur. Proper venting of the mold will eliminate this problem completely.

As stated above, the depth of the face on the cavity openings is important, and must be held within 0.001-0.0015-inch. Width is not really important, but as much as 60% of the cavity can be vented. In the case of high-speed thin-container molding, it should be vented to this extent. The answer to proper venting is not necessarily the width of the vents or the amount of the vent,

* Chief Engineer, Mack Molding Co., Inc., Wayne, New Jersey

out the length of the land of the vent extending outward from the cavity itself. This length of land should be held from a minimum of 0.045-inch to a maximum of approximately 0.060-inch to the depth described above. Beyond this land length, the mold should be relieved at least 1/32-inch in depth, and preferably 1/16-inch in depth to the atmosphere. As volatiles condense on this short land length, they also will plug the mold momentarily. However, pressure built-up within the cavity is great enough so that the vent becomes self-cleaning with the exit of gasses from the cavity.

As stated above, many problems of molding are blamed on mold construction. A short time ago, the writer talked to the SPE Chicago group on "Runnerless Molding". After the meeting, a molder from the general area told me that he was molding thermoplastic dinner plates. He was having a lot of stress-cracking around the gate area, and asked if this could be corrected by adding runnerless nozzles. My answer was "No"; this was not a gating problem, but was one of venting. After discussing the job with the molder at great length, he agreed that I was right. I asked him to start-up the mold in the morning after having cleaned the vents with carbon tetrachloride and see how it would run. He replied that this had already been done. Actually, when the mold was put in operation the first time, it ran fine for two or three hours. Then, they took out the mold, did a little work on it, and cleaned off all the surfaces. After this, it again ran very well for a while, but suddenly pressures had to be increased and temperatures had to be raised to fill his cavities.

I've encountered this same problem before on the molding of a dinner plate in another plant. The following is a copy of a letter from the customer giving us actual production results:

"We are writing this letter to tell you how much we appreciate the suggestions you made with reference to venting our dies. We have found that after we had vented a die according to your recommendations leaving 0.0015" for the air to escape in eight or 10 places, depending on the size of the molded pieces, we increased the production from 60 to 90 shots per hour. We also reduced the material weight by 7%.

This enabled us to fill the cavity more rapidly and without flash, which in most cases saved as much as four cents on the large pieces. Formerly, when we molded these parts without the vents, we always had a flash because of the extra pressure that was required to fill the cavity properly."

This letter was received from and signed by the President of one of our very large custom injection molders, who has been in the business for many, many years.

It is needless to go further in selling you on the idea of the importance of proper venting in injection molds. Just study the quotation above and translate it into dollars and cents. With proper venting and, of course, proper gating, it is possible not only to eliminate secondary operations and speed-up production, but also to cut wall thicknesses in many cases since a mold that is well vented will produce a part having a minimum number of strains, adding greatly to the strength of the molded piece. —THE END

Presenting creep data on reinforced plastics

(*Cont'd. from page 47*)

the exception of the room-temperature data, use of the modifications discussed decreased the deviation from the conventional curve. The large deviations noted when using the modified methods on the room-temperature data probably is due to the extremely-short tests used. Application of these methods to the data contained in the conventional curve resulted in much smaller deviations.

The effectiveness of the Larson-Miller parameter as used by Goldfein is very limited when handling the data presented in Table 5. This is best seen by examining the lower curve of Figure 7, in which this data is plotted. When the curve is located by points taken from the individual curves presented in Figures 6 and 7, the resulting plot becomes valuable in calculating longer tests and also tests at intermediate temperatures.

Conclusions

In summation, two methods for presenting stress-rupture data have been discussed. Both appear helpful for comparing materials, and depend on the stability of the laminate at the test temperatures.

The Sampson-Vondracek method is an effective method for obtaining a stress versus rupture life curve from a set of data. This method should reduce testing costs by reducing the effect of scatter in the test results.

The Goldfein method is a useful method, but is most effective when the scatter in test results is small. This method should reduce testing costs because only one master curve need be made. Indications are that rupture times may be calculated from the master curve for all test conditions which do not cause structural changes in the laminate.

Preliminary trials indicate that the Sampson-Vondracek method can be improved by relocating the tensile value.

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—THE END

Dr. S. S. Stivala

J. J. Scavuzzo

Consultants' column

Pleased to meet you

J. J. Scavuzzo *
and
Dr. S. S. Stivala **

Consistent with PLASTICS TECHNOLOGY'S aim to serve the plastics industry and all who use plastics as engineering materials, this column has been added to the Engineering Forum section of the magazine. Its objective is to answer or present guide lines for the solution of your problems in the processing, fabrication, design, and application of plastics in product engineering.

In succeeding articles, we will discuss and answer specific questions which you, the readers, submit. Since the value of this column depends on your active participation and interest, we ask reader assistance in selecting the most interesting subjects for discussion and a continuing supply of questions and problems.

The plastics designer and engineer, in addition to technical problems, has to contend with the extremely difficult obstacle of attitude towards plastics. Since Hyatt and Bakeland, plastics have taken tremendous strides in attaining their current significant positions as engineering materials. The concept that plastics are "substitute" materials is not valid, since many of their properties are unique and unavailable in any other material.

Unfortunately, many designers and engineers still view plastics with skepticism. This attitude is a carry-over from the period when many plastics were improperly applied—low material and fabrication costs were the criteria of choice rather than service life of the end-products. Though not so prevalent as before, this attitude must be eliminated by the elimination of all improper practices and poor designing if the plastics industry is to realize its full potential.

A listing of improper applications would be irrelevant, but the need for continued up-grading of performance, and realization and acceptance of proper design parameters peculiar to plastics are imperative. Designers and engineers considering a plastics application should be familiar with the material's physicals, the fabrication methods, and the problems incident with both. Mold temperature, pressure, cure time, type of mold, and flow pattern can and do affect the physical properties and, therefore, the performance of plastic products. Proper mold design and molding procedures minimize or eliminate physical degradation, but cannot compensate for poor product design and material selection.

Plastics confront the designer with unique problems such as creep, apparent modulus, aging, heat-time response, and varying structural properties at different rates of loading. This problem become even more complex when we consider such response mechanisms as weathering, compatability, and dimensional stability.

Reinforced plastics users must consider and compensate for such design factors as directional response, interface bond, and interaction between the material components. Reliable design data are not available, since classic structural analysis is based on the assumption that the material is homogeneous.

Good plastic design should evaluate all factors involved. The penalty for ignoring or incompletely analyzing these design parameters can and has resulted in failure for the designer, and a black mark against the industry.

The plastics industry has made outstanding progress in the past decade and, with continued fine engineering and development, will attain its maximum potential.

Again, the value of this series depends upon your cooperation and interest—manifested by questions directed at us. We look forward to assisting you in your problems.

—THE END

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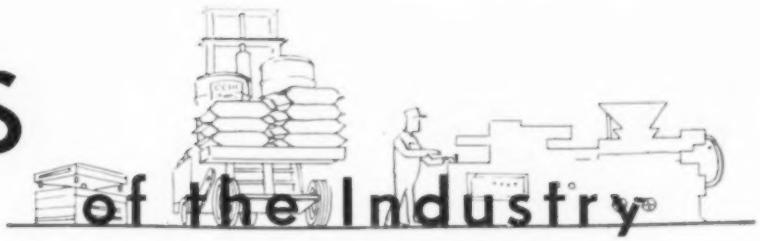
NEWS of the Industry



business developments

Spencer Chemical, holder of U. S. licensing rights to the Thermofusion process (a method of producing large shapes by the fusion of powdered thermoplastic in inexpensive molds), has granted same to American Agile, Amos Molded Plastics, Loma Plastics, Rubbermaid, and Space Structures, Inc. The process was deveoped in Europe by Thomas Engel, and was described as the Engel process in "What's New in Processing" in our March issue.

Visking Co., a division of Union Carbide Corp., has made available dispenser-type packages of Visqueen polyethylene film. The rolls are 50 feet in length, and are available in widths 3-20 feet, thicknesses of 4 and 6 mils, and in black and natural.

Timely Technical Products, Inc., Whippany, N. J. has expanded its Teflon engineering service from a local to a national basis. This includes die design and the compounding of special additives.

Reynolds Metals Co. has elevated its plastics department to full divisional status, with Woodrow J. Vogel, former general market manager, as general manager of the new division.

Phenolic sales topped the half billion pound mark in 1959, a 23% increase over the previous year. Industry leaders predict a steady climb through the sixties.

McCordi Corp., Mamaroneck N. Y., has installed equipment for direct or stretch lamination of Videne film to numerous flexible materials. The film is a polyester produced for protective and decorative applications by Goodyear Tire & Rubber Co.

Chippewa Plastics Co. has begun production of polypropylene film. Present production is limited to translucent blown tubing for special industrial applications.

Armour Alliance Industries, a division of Armour & Co., added flexible polyurethane foam to its line of cushioning and packaging materials. A plant is under construction in Los Angeles, and should open this month.

An Industrial Container Institute was formed by the Society of the Plastics Industry, with Jerome S. Heisler as chairman. The group will be concerned with plastic containers of one-gallon capacity or larger, and is not to be confused with the plastic bottle and tube manufacturers' institute. The latter is a SPI division dealing with containers of a smaller capacity.

Pittsburgh Coke & Chemical Co. has consolidated its three chemical divisions into a new, wholly-owned subsidiary company called Pittsburgh Chemical Co. The divisions involved are the activated carbon, protective coatings, and industrial chemicals.

Continental Can Co. has set up plastic bottle production facilities in Los Angeles, Baltimore, and Cincinnati, to supplement the production offered by its present Chicago plant.

new plants, labs & additions

H. Muehlstein & Co., Inc., has moved its home office from 60 E. 42nd St., New York City, to 521 Fifth Ave. Greatly increased facilities will enable the firm to concentrate all its home activities at one location. Muehlstein is reportedly the world's largest dealer in virgin, secondary, and reprocessed plastics and rubber.

Dow Chemical Co. plans to erect a phenol plant at Kalama, Wash., with completion scheduled for mid-1961. The plant will have a capacity of 36-million pounds per year.

Synthane Corp. has established fabricating and warehouse facilities in Glendale, Calif. Bert C. Kibre has been named manager of West Coast operations.

Dow Chemical Co.'s James River division plans to construct a nylon 6 plant at Williamsburg, Va. Completion is set for late 1961, and initial capacity should be 12-million pounds of filament yarn annually.

Federal Pacific Electric Co. has opened a 35,000 square foot plastics processing plant in Newark, N. J. The facility will compound, preform, mold, and machine finish plastic components for the company's line of circuit breakers, switches, and metal-clad switchgear. Plant capacity is 500,000 pounds of material processed per month.

Cary Chemicals, Inc., has opened new facilities at Flemington, N. J., which will provide 50-million pounds of PVC homopolymer and copolymer resins annually. In addition to this tripling of productive capacity, Cary has expanded its compounding facilities in East Brunswick to provide a minimum of 36-million pounds of compounds annually. New pilot plants are now in operation at both Flemington and East Brunswick, thus permitting greatly intensified product development.

Protective Spray Plastics, Inc., has moved to larger quarters at 830 Morris Ave., Bronx, N. Y. Exclusive distributors of the vinyl "cocoon," the firm was located previously at 507 Fifth Ave., in New York City.

Union Carbide Chemicals Co. has opened a technical service laboratory in Tarrytown, N. Y. The new facility centralizes and expands Carbide's customer service and use research that had been carried out principally at Mellon Institute and at the firm's other affiliated laboratories.

Axel Plastics Research Laboratories recently moved to new quarters at 1070 Manhattan Ave., Brooklyn 22, N. Y. The firm simultaneously announced the development of a new type mold release for polyurethane foams.

Sterling Extruder Corp., has moved from 1112 Baltimore Ave. to a larger plant at 1537 W. Elizabeth Ave., in Linden, N. J.

Borden Chemical Co. has erected its fifth West-Coast plant at Fremont, Calif., for the production of 90 million pounds of resin and formaldehyde annually.

PLASTICS TECHNOLOGY

EXPLORING FABRICATION TECHNIQUES

By L. J. ZUKOR, *Engineering Editor*

Polypropylene. . . .

. . . in less than two years of commercial availability, is being used in an increasing number of applications. Injection-molded, extruded, and blow-molded products, film, sheeting, and fiber are some of the manufactured items formed from this polymer. Because of its overall adaptability, polypropylene shows promise of becoming one of the most versatile thermoplastics known. The reason for this versatility is its unique combination of physical properties such as; low density 0.9g./c.c. (floats in water), very low water absorption (0.01% maximum), high tensile strength (100,000 psi.), chemical resistance, excellent dielectric strength (650 volts/mil), and complete resistance to environmental stress cracking (ESC).

Since polypropylene differs widely in physical characteristics from its closest relative, polyethylene, and in order to help you to better understand the requirements of the fabrication method described further on in this column, a short description of the laboratory development is included.

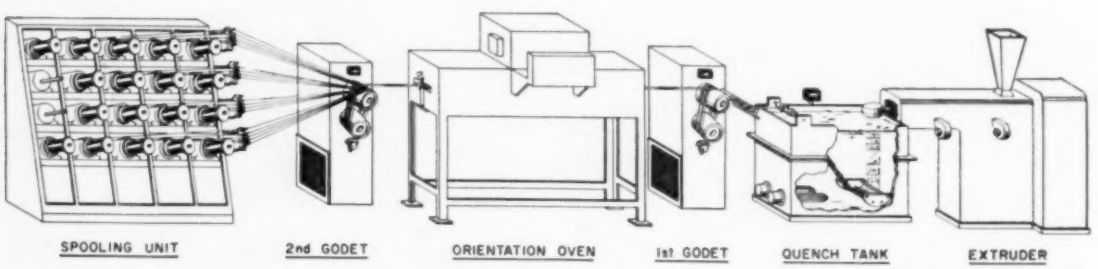
Prior to 1954, propylene could not be polymerized. All attempts to initiate polymerization with the then known cationic catalysts such as aluminum chloride (used in the polyethylene process) failed or produced only heavy oil products. In the latter part of 1953, Professor Karl Ziegler observed that titanium tetrachloride in combination with an organo-aluminum compound such as aluminum triethyl would polymerize ethylene at relatively low temperatures and pressures. This success led Professor Giulio Natta, to attempt the polymerization of propylene using these same catalysts. His success in producing a propylene polymer by this method led to subsequent investigations in which titanium trichloride was substituted for the tetrachloride. The trichloride system produced a more crystalline polymer than did the tetrachloride system.* Professor Natta identified polypropylene as a linear, partially crystalline polymer consisting of three varieties, which he called atactic (non crystalline or amorphous), isotactic (crystalline), and stereoblock (chain molecules containing adjacent blocks of atactic and isotactic configurations).

Polypropylene, as removed from the reactor, always contains a mixture of the three stereoisomers, the ratio depending upon the catalyst composition and polymerization conditions. By selection of the proper catalyst and set of polymerization conditions, almost any ratio of the three polymeric variations can be produced. This allows a wide range of polypropylene types to be produced having varying degrees of rigidity, processability, and toughness. Another point of interest is that the atactic polymer is soft and elastomeric, has a low softening point, and a non-definable melt point. In contrast, the isotactic polymer has a well defined melting point of about 347° F., and is a stiff, crystalline solid.

These developments were quickly recognized by a large number of companies. Presently there are about seven companies manufacturing and marketing polypropylene in this country. The first American company to offer polypropylene was Hercules Powder Co.

Recently, other members of the press and myself were present at the opening of the latest polypropylene production facility to go on stream—the new Humble plant in Baytown, Texas. Before enplaning for Texas, we visited the Enjay Laboratories'** new plastics wing. One of the interesting highlights seen during the tour was the perfected technique used in the extrusion of polypropylene monofilaments. Studies made on this

* Titanium trichloride and triisobutylaluminum catalyst in octane has been reported to give a very high degree of crystallinity to polypropylene.
** Enjay Laboratories and Humble Oil Co. are both Standard Oil (N. J.) affiliates.



Polypropylene monofilament extrusion line.

Diagram courtesy: Enjay Laboratories

Photo courtesy: Enjay Laboratories

Extruding monofilaments downward into water bath.

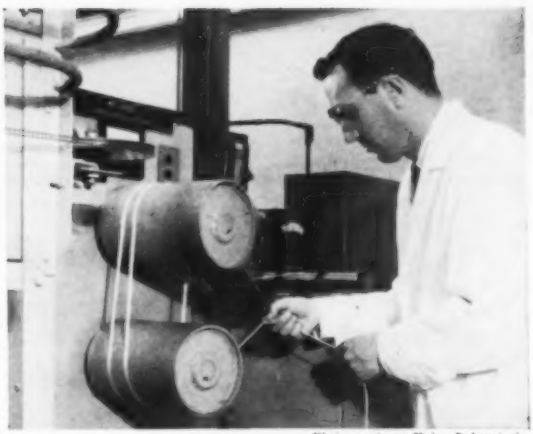


Photo courtesy: Enjay Laboratories

Threading filaments over first Godet unit (variable speed capstain).

manufacturing set-up indicated that the strongest fibers are made from resins of high molecular weight (low melt index) and high crystallinity (high resin density). Maximum strength (tenacity) is obtained in the filament when it is processed at relatively low melt temperatures and high orientation temperatures. The processing studies were carried out on commercially available apparatus. The extruder is a 1½-inch, 24:1 L/D ratio, vented type. Eighteen strands are extruded downward into the quench tank through 52-mill diameter orifices. With the extruder output set at 15-lbs./hour, monofilaments are pulled from the water bath by the first Godet unit at a velocity of 40-feet/min. This velocity matches the extruder output so that the filament, at this point, is under no tensile load. After being taken up by the first Godet, the fibers are stretched in the orientation oven between the first and second Godets. Stretching or draw-down of the filaments is accomplished in a 300° F. air oven by running the second Godet units, from 6-10 times the speed of the first Godet.

Experimental results obtained from working with resins of low and high melt indexes indicated that the following set of optimum conditions produced the strongest fiber: resin melt index of 1.27; extrusion temperature of 425° F. (minimum); water bath temperature limited to 120° F. (so that localized boiling will not mar the extrudate); and orientation oven temperature limited to 350° F. (polypropylene will melt at higher temperatures). This set of conditions produced a fiber with a tenacity of 8.01-g./denier.

Monofilaments produced from polypropylene exhibit good knot strength; high resilience; good abrasion resistance; and are immune to attack by fungi, moths, and marine organisms. Large diameter marine hawsers fabricated from the filaments are easy to handle and do not sink. They remain flexible at temperatures as low as —70° F., and they do not have the slippery, waxy feel associated with polyethylene. Polypropylene has a breaking strength that is 50-75% greater than manila, and a strength to weight ratio second only to nylon. Because of its low residual elongation after orientation (alignment of the crystallites by draw-down), window-screening, webbing, and auto-seat coverings are other items which are fabricated from these monofilaments.

A heartening thing that I see today in the plastics industry is the intensified research programs being carried on by many well staffed and fully equipped laboratories. It is in these laboratories, such as the one seen at Enjay, that integrated concerted effort can bring about earlier commercialization of research projects.

—THE END

Photo courtesy: Enjay Laboratories

Stretching (draw-down) of monofilaments in an orientation oven with controlled temperature.

Photo courtesy: Enjay Laboratories

Monofilament take-up on spools—drawn down from 52 mils to 6-12 mils.

HERCULES

Plastics Hi-Lites

Vol. II, No. 3

New Housing Projects, 1960 Style

Product builders achieve significant improvements with Pro-fax® polypropylene

BULLETIN

WASHINGTON, D. C. . . . The Food & Drug Administration has issued a formal regulation, appearing in the Federal Register, authorizing the use of Pro-fax polypropylene in products coming in direct contact with all kinds of food. Pro-fax thus becomes the first packaging material to win approval through the issuance of a formal Food Additives regulation. Author of the successful petition was Hercules Powder Company. Hercules predicts widespread use of Pro-fax in food uses, including packaging films, molded containers, coatings, liners and dispensers used in food handling.

Plastic housings in all manner of sizes and shapes, used in an across-the-board list of products, are among the first big developments of the '60s . . . an exciting clue to things ahead. Materials such as Pro-fax polypropylene are fast changing the face and function of many a product, lending new color and styling appeal, improved performance, and above all—*lower cost!*

Measured by yesterday's standards the achievements of today's new materials border on the impossible: they provide high resistance to heat, moisture, household chemicals, foods and cosmetics. They offer rich color and are ideally adapted to the attractive styling requisite for modern merchandising. Yet because they are low-cost materials, adaptable to rapid cycle injection-molding, they are *priced right!*

No wonder that just about every new plastic housing project you see these days is a Pro-fax project. Here are a few of the latest.

AROUND THE YARD

A handsome Pro-fax housing is the new symbol of quality on today's modern power mower. An excellent example is this high-styled motor shroud for the 1960 Power-Matic. Its beauty belies its rugged strength, for this sturdy housing is virtually unbreakable and will permanently resist heat, moisture, gasoline, oils and greases. Molded-in mountings eliminate the need for metal parts in the assembly, providing a design that is completely corrosion-proof. In addition to the Power-Matic shroud, Amos Molded Plastics, Edinburg, Indiana, has designed, developed and produced a series of similarly well-engineered Pro-fax mower housings for Power Equipment, Cicero, Indiana, and its value-conscious customers.

IN THE KITCHEN

Pro-fax in the kitchen spells new convenience and satisfaction for homemakers. Knapp-Monarch's Redi-Matic automatic can opener-knife sharpener features a gleaming white Pro-fax housing, and as a result is impervious to damage from staining and rough handling. The Redi-Matic automatically opens cans of all shapes, and sharpens knives of all sizes. Thanks to Pro-fax, it's a luxury styled unit designed to blend beautifully with any kitchen decor.

Molded by: Warren Molded Plastics, Cortland, Ohio.

ABOUT THE HOUSE

Fast becoming standard home accessories, vaporizers and humidifiers have gotten a big boost in appearance and function by the use of Pro-fax. The new Northern automatic vaporizer/humidifier (shown here) features a bowl and lid molded with Pro-fax, in contrasting colors, which combine in a compact, easy-to-carry appliance that is both useful and attractive wherever it serves in the house.

Pro-fax bowl and lid molded by Cruver Manufacturing Company, Chicago, Illinois.

IN THE NURSERY

Modern style and top performance go hand in hand in Formulette's bottle warmer. It's molded with Pro-fax, of course, for a luxury finish plus resistance to heat and moisture, in a rigid, thin-walled, lightweight unit that is easy to handle, always safe and the ultimate in completely sanitary nursery equipment.

Molded by Boonton Molding Company, Boonton, New Jersey, for Formulette Company, Inc., Jamaica, New York.

IN THE LUNCH BOX

Breadwinners, too, enjoy the convenience and luxury of Pro-fax. The handle, jacket, and collar of Aladdin's new Dura-Clad vacuum bottle, with its unique "Pitcher-Pour" handle, are all molded in one piece with Pro-fax. Pint-size (shown here in use) fits all workmen's lunch kits while the quart size (appearing in the background) is designed to fit conventional outing kits. Both models are heat-, scratch-, and stain-proof.

GP60-9

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

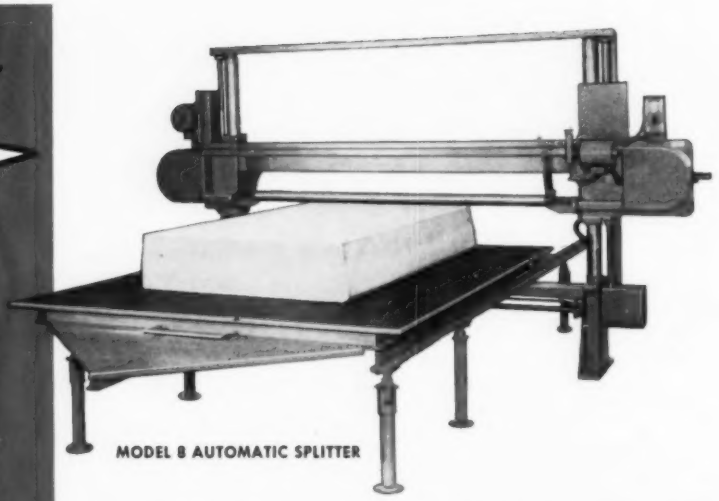
THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

HERCULES

2

New Machines Made Especially for Fabricators and Producers of Flexible Foam Materials

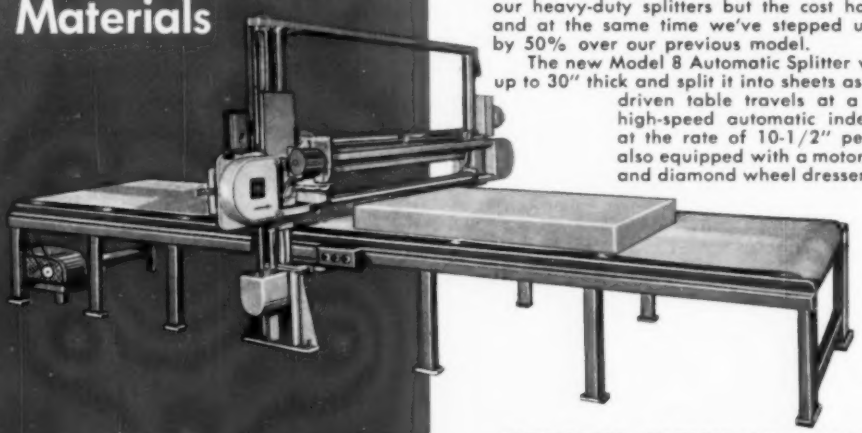


MODEL 8 AUTOMATIC SPLITTER

20% LESS COST! 50% MORE PRODUCTION!

Here's our new Model 8 Automatic Splitter, a completely automatic machine made especially for fabricators and producers of urethane and other synthetic foams. It has all the features of our heavy-duty splitters but the cost has been reduced by 20% and at the same time we've stepped up its production capacity by 50% over our previous model.

The new Model 8 Automatic Splitter will handle a bun of foam up to 30" thick and split it into sheets as thin as 1/16". Its power-driven table travels at a rate of 75 FPM and its high-speed automatic indexing mechanism indexes at the rate of 10-1/2" per minute. The machine is also equipped with a motorized dual wheel sharpener and diamond wheel dresser.



MODEL 7820 CONVEYORIZED SLAB CUTTER

GREATER FLEXIBILITY AND ECONOMY!

FEMCO's new semi-automatic Conveyorized Slab Cutter with push-button control is priced well within your budget as a fabricator or producer of flexible foam material. It will give added flexibility to your operation enabling you to buy longer blocks of stock at lower costs and process them into sheets of any desired thickness right in your own plant.

With a conveyorized machine such as this, you're not limited as to the length of stock you can handle. It will take a block of foam 78" wide x 10' long x 30" thick. With idler rollers added, it can handle blocks up to 40' long. You can also batch process blocks of stock. One distributor is currently processing 25 blocks of foam 20" thick x 6' wide x 6' long into 4" thick slabs in just 25 minutes with this type machine.

The new Conveyorized Slab Cutter has a belt speed that is variable from 25 to 100 FPM. The conveyor can be run in one continuous direction for batch processing or reversed for reciprocal block cutting.

You can use our FEF plan to finance the purchase of any FEMCO machine. Complete details are available upon request. Movies of all FEMCO equipment in operation will be shown right in your office by one of our qualified sales representatives. Call or write now and set the date.

FEMCO

1917 43rd YEAR OF SERVICE 1960

The FALLS ENGINEERING AND MACHINE CO.

CUYAHOGA FALLS, O.

Both of the machines featured here are equipped with FEMCO's new never-change guide bar coated with "Fem-Coat" slick surface to reduce frictional drag and minimize static electricity. Bar will permit splitting from 1/16" to 6" accurately.

New Materials

For more information check Readers' Service Card (p. 77)

Low Molecular Weight PE

To its line of Epolene polyethylene resins, Eastman Chemical Products, Inc., has added three low molecular weight polyethylenes: LVE (low viscosity, emulsifiable); HDE (high density, emulsifiable); and HD (high density). According to the company, the resins will be used in improving injection molding of polyethylene, as additives to rubber to serve as calender and mold release agents, and as lubricants in extrusion.

Both LVE and HDE have desirable properties for floor wax formulations. LVE is reported to have good anti-slip properties and rebuffability in floor polishes, while HDE, which may be handled as a wax, deposits a hard film in self-polishing formulations. Because of its hardness, HD type is recommended for printing ink; it can be ground with ink vehicles into a fine dispersion which is stable and has little tendency to separate. Properties are:

	LVE	HDE	HD
Emulsifiable	Yes	Yes	No
Density	0.939	0.956	0.938
Approximate molecular weight	1,500	1,500	1,500
Brookfield viscosity, cp., 160° C.	170	160	150
140° C.	250	265	220
120° C.	400	455	340
Penetration hardness, tenths of mm., 100 gm./5 sec./77° F.	5	1	0.5

Readers' Service Item 1

Modified Epoxy Adhesive

Availability of a 100%-solids, unfilled, modified epoxy adhesive, Bondmaster M685, has been announced by Rubber & Asbestos Corp. The two-part, room temperature-curing formulation was originally developed for bonding rigid expanded polystyrene to rigid surfaces under unusual service conditions or at operating temperatures over 120° F. It is recommended, among other applications, for sandwich panel fabrication.

A free-flowing (about 3,000-7,000 cps.), intermediate strength, clear pale amber liquid, the adhesive, when mixed with hardener, weighs about 9.6 pounds per gallon. Pot life, depending on hardener, size of batch, and depth of container, is 45-90 minutes. At room temperature, the bonded assembly may be handled in 6-8 hours and develops 85% of maximum strength within 24 hours. The formulation may be heat cured in as little as 10 minutes at 250° F. with one of the hardeners available.

Readers' Service Item 2

Heat-Resistant Laminate

A grade of Dilecto laminate designed for use in missiles and other applications that require exceptional heat resistance has been announced by Continental-Diamond Fibre Corp. Made by impregnating graphite fabric with a heat-resistant phenolic resin, this development material is designated N-104-84-2. Laboratory samples have been made available to companies that have a "DX-A2" Ballistic Missile Program priority. Samples are either laminated six-inch squares in thicknesses to ½ inch; or three-inch diameter cylindrical moldings, made from macerated impregnated fabric, in depths to two inches.

In laboratory ablation tests, a six-inch square, ¼-inch thick sample was exposed to a 5,000° F. flame. It required more than ten minutes to burn through the sample, giving it a burn-through rate of less than 0.0005 inches per second. Other properties are shown in the following table. Properties are based on a laminate that was not post-cured.

Thickness, inches	0.131
Tensile strength, psi., lengthwise	13,000
Crosswise	10,000
Flexural strength, flatwise, psi., lengthwise	24,900
Crosswise	24,200
Impact strength, Izod, ft.-lbs./in. notch, flatwise, lengthwise	1.12
Crosswise	1.13
Dielectric strength, volts/mil	7
Compressive strength, flatwise, psi.	34,400
Rockwell hardness, M.	117

Readers' Service Item 3

Epoxy Laminating Systems

Two non-irritant epoxy laminating systems have been placed on the market by Marblette Corp. Maraset laminating resin #607-AA and brilliant white gel coat #606, with safety hardeners specifically formulated for each resin, were developed to reduce or eliminate allergic reactions which sometimes occur in susceptible individuals.

The special catalysts are non-fuming, relatively odorless, and readily mixable with the resins. Since they are non-hygroscopic, they will set up even under humid conditions for a room temperature cure providing tack-free surfaces.

Maraset #606 is used to coat the surface of a mold or model when it is not desirable to have the pattern or texture of the glass fiber showing, while #607-AA is recommended for fiberglass-reinforced tools. Some physical properties of the materials are:

	#607-AA	#606
Potlife, minutes	15–20	15–20
Impact strength, ft.-lbs./in. unnotched Izod, cast	2.0	1.75
Laminate	30.0	—
Tensile strength, psi., dry	31,700	—
Flexural strength, psi.	36,900	—
Flexural modulus, psi. 10^6	3.5	—
Compressive strength, psi	27,600	17,500
Interlaminar shear strength, psi	2,800	—
Shrinkage from mold, laminate, in./ft.	0.0025	—
Casting, in./ft.	—	0.0032
Hardness, Rockwell M.	85	88
Cold creep, 1 x 1 x 8 in. sample, 3 lb. load	0.09	—
Taber wear index, 1,000 cycles, wheel CS-17, wt. 1,000 gms.	—	55

Readers' Service Item 4

Specialty Adhesive

Raybestos-Manhattan, Inc., is currently marketing a bonding agent for Mylar, polyethylene, glass, and other slick-surfaced, bond-resistant materials which are normally sealed together over a wide temperature range. Intended primarily for non-structural applications, R-84002 is based on a thermoplastic resin. Bond is obtained upon solidification; rate is dependent on ambient temperature and temperature of materials being processed.

As sold, this brown adhesive is 100% solids. It should be heated to 250° F. for applications. For short periods, the temperature may be increased to 300° F.; however, at this temperature the material begins to decompose. Temperature tolerances are from -20 to 200° F.

Readers' Service Item 5

Polypropylene Resin

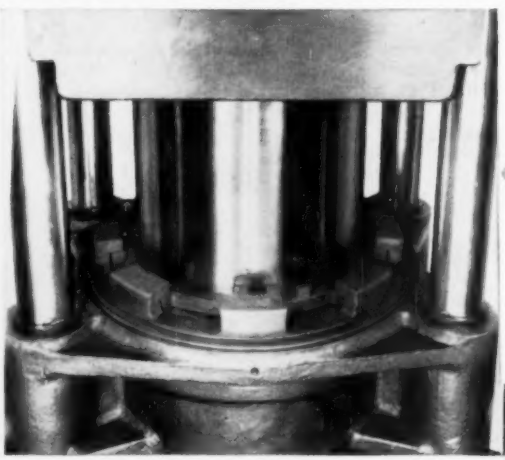
Enjay Chemical Co., division of Humble Oil & Refining Co., has developed a polypropylene resin which can be fabricated into parts having a tough, mar-resistant surface with high gloss and excellent finish. Available under the name Escon, this resin may be processed by all methods employed with thermoplastics.

High strength and excellent chemical and abrasion resistant qualities recommend Escon for injection molding. Flat film extrusion, produced by water bath or chill roll technique, provide clarity and gloss, have good vapor barrier properties, and may be sterilized by heat and chemical means. Sheeting may be extruded for such operations as thermoforming, punching, machining, and die cutting. Pigmentation before or during extrusion produces brightly colored sheet stock.

... as usual by STEWART BOLLING.

EXCLUSIVE Feature Trims Press Packer Replacement Time and Removes Other Maintenance Drawbacks

STEWART BOLLING BREECH BLOCK DESIGN



Close-up of Stewart Bolling breech block design holding press packer and gland ring.

FEATURES

- NO STUDS AND NUTS IN GLAND RINGS
- NO SCORING OF RAM
- NO PACKER DAMAGE
- SELF-LEVELING

Minutes, not hours! Pennies, not dollars! That's what still another exclusive development of Stewart Bolling's 30-year background has done to press maintenance. This new and latest feature, the Bolling breech block design (patented), eliminates studs and nuts in press gland rings. Self-leveling, it prevents ram scoring, stud breakage and packer damage. Packer replacement takes minutes. This new design can be had on 1959 Stewart Bolling presses.

Stewart Bolling
& Company, Inc.
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Designers and Builders of Machinery for the Rubber and Plastics Industries
Intensive Mixers • Calenders • Mills • Refiners • Crackers • Dust Grinders • Sheeters
Hydraulic Presses • Pump Units • Accumulators • Elevators • Bale Splitters • Vulcanizers
Speed Reducers • Gears • Extruders

Slow-burning, the material has excellent machining qualities. The range of values in the physical property tabulation encompasses the different grades of Escon.

Density, 73° F., g./cc.	0.987–0.910
Melt index, 250° C., g./10 min.	1–10
Mold shrinkage, in./in.	0.015–0.030
Water absorption, %	<0.01
Yield strength, psi., 2 in./min.	2,800–5,100
Tensile strength, psi., 2 in./min.	2,500–4,900
Yield elongation, %, 2 in./min.	13–18
Ultimate elongation, %, 2 in./min.	22–315
Impact strength, ft.-lb./in., Izod notched	1
Izod unnotched	>16
Hardness, Rockwell R.	80–90
Shore D	70–75
Elastic modulus, psi., 2 in./min.	45,000–60,000
Flexural modulus of elasticity, psi., 2 in./min.	111,000–176,000
Flexural modulus of rupture, psi., 0.05 in./min., no break, max. load	65,000–81,000
Compressive yield stress, psi., 0.05 in./min.	5,300–6,400
Compressive strain at yield, %, 0.05 in./min.	15
Compressive elastic modulus, psi., 0.05 in./min.	53,000–63,000
Stiffness in flexure, psi.	95,000–150,000
Modulus of elasticity, psi.	100,000–128,000
Taber abrasion, mg. loss/1,000 cycles, CS-17 wheel, 1,000 g. load	29–32
Melting point, °F.	335
Vicat softening point, 1 kg., °F.	266–293
Deflection temperature, °F., 264 psi. fiber stress °F., 66 psi. fiber stress	188
Coefficient of thermal conductivity, cal./cm./cm.²/sec./°C.	2.80×10^{-4}
BTU/in./ft.²/hr./°F.	1.13
Coefficient of linear thermal expansion, in./in./°C.	0.00020
Specific heat, 73° F., ca./g.	0.46
Dielectric constant, 10^6 cycles	2.0

Readers' Service Item 6

Film-Supported Adhesive

Reichhold Chemicals, Inc., has introduced Plyophen 2000-PGL, a continuous dry film of phenolic resin supported on a cellulosic carrier. As an industrial adhesive, the product eliminates the need for glue spreading equipment when used in bonding plastic overlay to wood, metal, or paper.

In practice, a sheet of the adhesive is placed between two surfaces, and the bond is cured in a hot press (usually 290-315° F.) or by high frequency field heating. Layups may be stored for considerable periods at normal temperature and humidity before pressing.

Plyophen 2000-PGL is supplied in roll form on a 6-inch I.D. core. Weight per 1,000 square feet is approximately 12.5 pounds. It is currently available in widths of 38, 50, and 62 inches, allowing a two-inch trim for 3, 4, and 5-foot-wide product manufacture.

Readers' Service Item 7

New Equipment

For more information check Readers' Service Card (p. 77)

FRL environmental test chamber.

Environmental Test Chamber

Custom Scientific Instruments, Inc. has redesigned its FRL environmental test chamber to be inserted into tensile testers from the front or the back. Resting on a hydraulic operated carriage, the chamber in divided vertically into a two compartment electric oven or ice chest. Temperature range is —90 to 750° F.

The cabinet measures 31 inches long by 24 inches high by 13½ to 20 inches wide, depending on the width of the tensile tester. Basic cabinet inside height is 18 inches. Inside working area is 17 inches deep by 9 to 14 inches wide. With a well for tension it is 24 inches high; for compression, 12 inches high.

Height from the bottom of the chamber to the floor can be adjusted from 28 to 43 inches.

Readers' Service Item 21

Penton Gate Valves

Throttlable Penton gate valves, generally resistant to all inorganic acids except fuming nitric and fuming sulfuric, are in production by Vanton Pump & Equipment Corp. Since the valves will not elongate at temperatures below 125° C., they are particularly suited for use in process operations that require continuous exposure to corrosive media at elevated temperatures.

Featuring straight through no pressure drop flow with close throttling control, the gate valves are available in sizes from ½ to two inches with socket weld, flanged, or screwed ends.

Readers' Service Item 22

Extreme Temperature Tester

The FRL Extreme Temperature Test Chamber, built by Custom Scientific Instruments, Inc., under license from Fabric Research Laboratories, Inc., makes possible tensile and compression tests on nonrigid materials at temperatures from —95° F. to 1,000° F. The FRL chamber, in conjunction with the Instron instruments for which it was principally designed, permits use of most normal jaws and allows tensile testing of ten-inch samples with up to 80% rupture extension. Precise control of the temperature range is ± 1-2° F.

This portable apparatus may also be used independently as an oven or cold chamber. Working space, about 3,000 cubic inches, measures 21 by 9.5 by 26 inches. Chambers and temperature ranges can be made to purchaser's specifications.

Readers' Service Item 23

Modular Infra Red Ovens

Infra Red Systems, Inc., has made available a modular infra red oven which can be made to fit any drying system; which gives uniform heat over entire emitting area; and which can be used with any conveyor. The basic module, RediRay, is a self-contained heater which uses a ceramic face as a source of radiation. The ceramic face is brought to emission temperature by formed resistance wire embedded in an insulating block behind it. The entire heating block is backed up by alternate layers of batt and reflective insulation and mounted in a metal shell.

Modules measuring 4 or 6 ft by 1 foot by 4 inches yield up to 500 watts per square foot radiation. Work temperatures go up to 400° F. Other units are available up to 2,000 watts per square foot and 1,500° F. work temperatures. Temperature control is accomplished with any adequate voltage control.

Readers' Service Item 24

Plastics Extruders

Stewart Bolling & Co., Inc., has developed a line of extruders with electrically heated barrels, reported to have exceptional temperature control.

Four-zone control of temperature in the barrel is partly accomplished by passing cool air between the hairpin-shaped elements, thus transferring heat directly from the barrel. Each zone, consisting of six bands of 500 watts each (about 20 watts per square inch), is cooled by a shaded pole blower with capacity of 3,220 feet per minute. A proportioning temperature controller has an electronic indicating unit with temperature range 200-600° F. for each zone. Required thermistor probes and contactors for the indicating unit are panel mounted.

Gear reducer, with 15:1 ratio, has 31 hp. in AGMA Class 1, with 900 rpm. input. Timken thrust device is integrally mounted in gear spider, with bearing thrust capacity of 87,300 pounds. The 2½-inch worm has circulating passage drilled. L/D ratio is 22:1; effective screw length is 54½ inches. Nominal capacity handled by drive unit is 200 pounds: screw speed to 60 rpm. is specified.

Readers' Service Item 25

Continuous Printing Machine

For continuous repeat printing of lettering or design on plastic tubing of diameters to 2 inches, Acromark Co. has developed Model No. 465. It is enclosed in a steel cabinet with the printing unit protected by a guard that permits only necessary access for die changes. An enclosed ink fountain with adjustable feed has a glass cover for visible refill. A knob on the work table adjusts a series of "V" rolls for plastic diameter and ink formulae.

The printing head is driven by a gear reduction motor. If several speeds are required for different tubes, a vari-speed unit can be included. The machine is about 20 inches wide, 38 inches high (including guard), and 12 inches deep. The power line plugs into any 110-220 volt A.C. outlet.

Readers' Service Item 26

Pre-Blanking Press

Reduction of scrap is the objective of a press for blanking thin plastic sheet developed by Emhart Manufacturing Co.'s Portland (Conn.) division. Equipped with continuous roll feed and automatic scrap cutter, the unit will blank printed or unprinted film at rates of 100-150 strokes per minute. Maximum width of material is 17 inches; thickness, 1/16 inch. Heavier gages require special handling. Finished blanks are automatically stacked in chutes for transfer to forming machines.

Readers' Service Item 27

Air and Hydraulic Cylinders

The Powrmation series of low pressure air and hydraulic cylinders are being offered by Hanna Engineering Works in bore sizes of 1½ through 8 inches. Capacities, depending on bore size, are 250 psi. air and 400-1,000 psi. hydraulic. Since the cylinders are available in a wide variety of mountings, rod diameters, and rod ends, they are adaptable to most installations.

NOW Controlled Tension From Start To Finish In Winding Roll-Fed Material

Never Before Anything So Efficient • Simple • Versatile

This is your chance to obtain a higher quality of wound material than ever before – and to save substantially on operating and maintenance costs at the same time.

You've never seen anything like the Hobbs "CHP" Winder. It's in a class by itself. No other winding device can match it for simplicity, efficiency and flexibility.

OPERATES ON A.C. Here is a squirrel cage three-phase A.C. motor, flange mounted to a gear reducer. It can be connected *directly* to your rewind shaft. It is entirely independent of the main machine drive. You plug it into your present three-phase power outlet – no transformers or converters to bother with. Then you set a knob to the desired tension and walk away.

AUTOMATICALLY SENSES TORQUE. From the start to the very finish of your rewind operation, the "CHP" accurately maintains the desired tension – protects even the most delicate materials from stretching, breaking or contracting. Automatically the "CHP" senses the increase in torque as the roll diameter builds up and it slows down the speed of the shaft in direct proportion. Controlled tension can be maintained in a roll build-up of as high as 10 to 1.

ECONOMICAL, FLEXIBLE. The efficiency of the "CHP" is many times greater than that of other types of winders. Maintenance is as slight as with any normal A.C. motor – there are no brushes or tubes. The "CHP" is compact, saves you floor space. It is clean, there are no belts to slip and stir up dirt. It is flexible – connect it directly to the rewind shaft, or remotely by chain and sprockets. And it needs no supervision, saves you labor costs.

MULTIPLE APPLICATIONS. The "CHP" Winder has already proved its adaptability and efficiency in multiple applications: – for winding, unwinding and inspection of paper, plastics, rubber and woven and non-woven textiles in a wide range of widths and weights.

Find out for yourself just why the Hobbs "CHP" Winder can make such a big difference – how it can give you increased production through *positive* quality control. Mail coupon below for free information. No obligation.

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D-M-E Corp., CLEVELAND, DAYTON; D-M-E of Canada, Inc., TORONTO

Strokes can be made to any practical length. An extra long bearing with an optional gland makes internal spacers unnecessary in many long stroke cylinders.

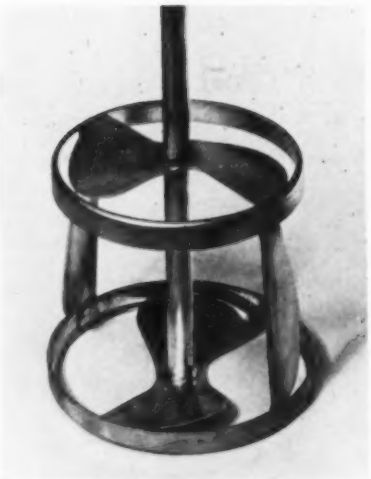
For strength, cylinder mountings are welded to one piece steel heads. A pressure-safe tube seal, located on the outside diameter of the tube, forms a positive seal against leakage. The destructive effects of heavy or high speed loads are minimized by a check seal cushion, claimed by the manufacturer to be a major improvement over earlier cushions.

Readers' Service Item 28

All-Purpose Mixers

The Jiffy Mixer is reported to effectively blend highly viscous substances such as putty, and at the same time eliminate splashing and assure blending of water-thin paints and varnishes.

Model H, which requires neither mounting nor clamping, can be operated by almost any existing chucked power tool. Two horizontal, axially opposed propellers mounted on a ¼-inch rotating mixer shaft draw the materials into a whirlpool. Splashing is eliminated by two peripherally-mounted vertical vanes. Furthermore, the vanes and the edges of the lower propeller remove any semi-solid deposits from the walls.



Model P Jiffy Mixer.

Heavy-duty Model P is similarly constructed. The shaft is ½ inch. Both units are constructed by Jiffy Mixer Co., Inc.

Readers' Service Item 29

Injection Mold Heat Circulator

Injection Molders Supply Co. has redesigned its circulator for maintaining injection mold heats over a temperature range from 50-250° F. The unit features a large thermometer for rapid temperature checks; all controls are protected by a heavy metal cover. It is supplied mounted on casters, with a 12 foot cord.

Motor supplied is ¼ hp., 1,725 rpm., 220 volt, 60 cycle, 1 phase, with built-in overload protection. Pump is 20 gpm. at 23-foot head, ¾-inch npt. outlet. Heat is supplied by a 4,500 watt, thermostatically controlled heater with heavy duty relay. Control range is 70-200° F. Large area copper coil for cooling is manually controlled by dual needle valves on inlet and outlet. The unit is 15 inches wide, 22½ inches long and 21½ inches high.

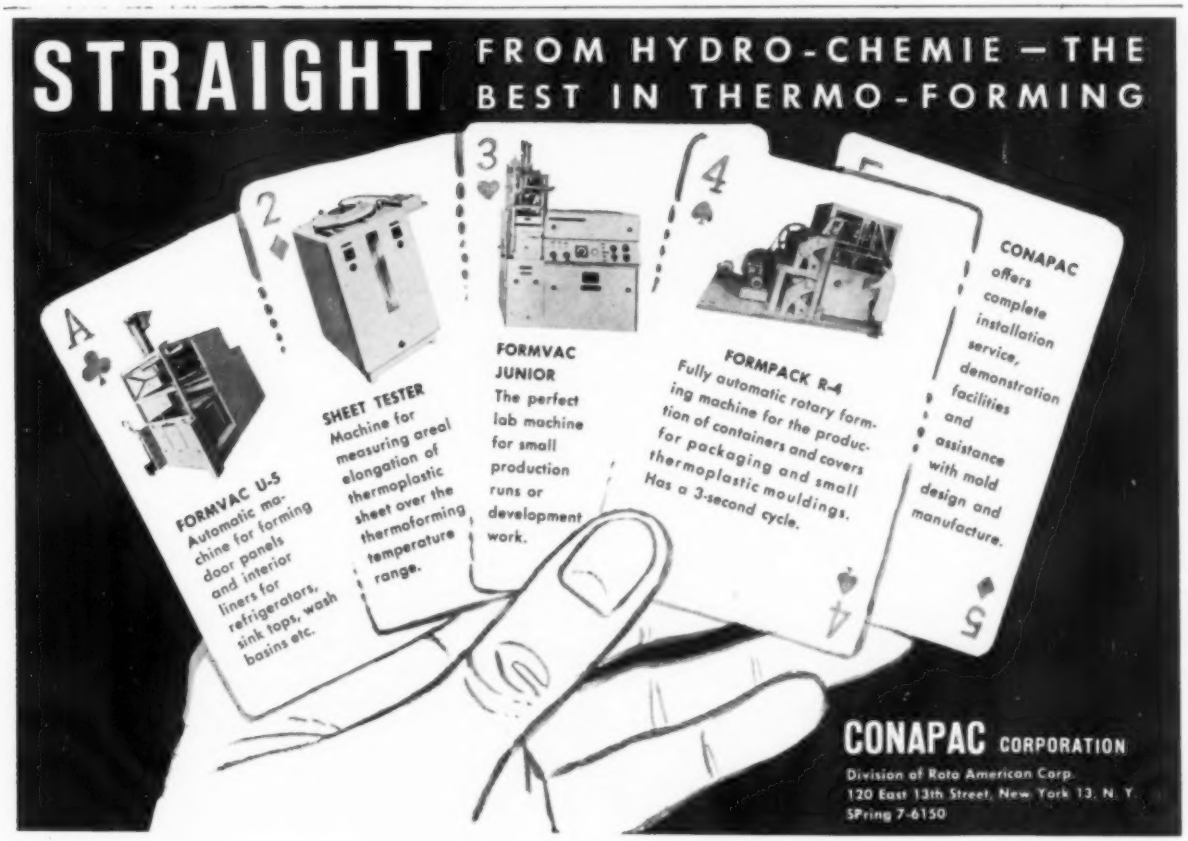
Readers' Service Item 30

RP Spray Systems

Rex Metal Parts Co., has announced three equipment combinations for producing fiberglass reinforced plastic shapes by the sprayup method. Each outfit incorporates the Rand gun, which sprays the self-curing resin mixture onto the form, eliminating expensive matching dies, mats, and press equipment. Available in two mobile and one stationary style, the equipment is recommended for large parts, such as car bodies, swimming pools, and furniture.

All three are equipped with swinging booms to widen the work area.

Readers' Service Item 31


STRAIGHT
FROM HYDRO-CHEMIE — THE BEST IN THERMO-FORMING
FORMVAC U-S
Automatic machine for forming door panels and interior liners for refrigerators, sink tops, wash basins etc.
SHEET TESTER
Machine for measuring areal elongation of thermoplastic sheet over the thermoforming temperature range.
FORMVAC JUNIOR
The perfect lab machine for small production runs or development work.
FORMPACK R-4
Fully automatic rotary forming machine for the production of containers and covers for packaging and small thermoplastic mouldings. Has a 3-second cycle.
CONAPAC offers complete installation service, demonstration facilities and assistance with mold design and manufacture.
CONAPAC CORPORATION
Division of Rota American Corp.
120 East 13th Street, New York 13, N. Y.
SPring 7-6150

Plastics Applications

For more information check Readers' Service Card (p. 77)

Open Koch Kamper.

Collapsible Camp Trailer

A compact camp trailer which has a low, cargo-type travel silhouette, pops up to full size in 20 seconds, and sleeps a family of six, has been unveiled by Koch Engineering Co. The Koch Kamper is of steel-reinforced fiberglass construction, with walls of 10-ounce army duck. The roof is reinforced with steel channels laminated into the fiberglass molding to permit portaging of a boat.

Dimensions and specifications are as follows: overall length, 152 inches; trailer length, 9 feet, 4 inches; length of hitch, 40 inches; height, open, 90 inches; closed, 48½ inches; wides, 7 feet; storage capacity, 1,000 pounds. Chassis: 2,000 pound, road tested capacity with 6:70 x 15 tires. Complete with full tail light assembly, including stop light, turn signals, and tail lights. Trailer floor: ⅝ inch exterior plywood, resin treated. All body joints: plastic sealed.

Readers' Service Item 41

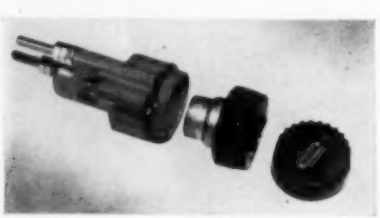
Alkyd Fuseholders

According to Fuse Indicator Corp., their Blow-Glow series of fuseholders, both indicating and non-indicating, possess the high arc and insulation resistance and dielectric values sought by the military for high altitude missile and rocket applications.

Blow-Glow blown fuse indicating Type EL-1 is already in use on the Nike-Ajax, Thor, and Polaris missile systems. Non-indicating Type 300-A and 400 are standard equipment on the Navy A4D Skyhawk and the Air Force X-15.

Plaskon alkyd molding compound 446 was selected for the fuseholders because of its superior electrical and mechanical properties and dimensional stability. Engineered Plastics, Inc., is the molder.

Readers' Service Item 42



Blow-Glow fuseholder.

Polyurethane Foam Pillow

A washable, allergy-free, contour pillow, created by Foamlab Co., provides sitting or reclining comfort in any position. Made with zippered, removable covers of washable pinwale corduroy, the pillow is supplied in 11 colors, with special school colors available for students. According to the manufacturer, the pillow is not affected by temperatures up to 300° F.; can be sterilized; will not oxidize, harden, or crumble; and is not affected by household cleaning agents or solvents.

The contour pillow is available in two models. The deluxe, with cord edges, is 13 inches high, 20 inches long, and 16 inches wide. The smaller model has a less expensive cover and plain edges.

Allergy-free contour pillow.

Readers' Service Item 43

Butyrate Relief Globe

Weber Costello has introduced the Tru-Vue relief globe, reported to be the first accurate relief globe ever produced, for use in geography classes. Actually two globes in one, a transparent butyrate shell molded in relief encases a regular blue or black world map.

The relief globe, molded of Midwest Plastic Products Co.'s Midlon B butyrate sheet stock, has elevations precisely plotted according to contour lines. The sheet's high clarity insures that the user can see through to the dark globe underneath. It will not discolor with age, or be affected by temperature changes. Further, the butyrate is markable and washable.

Tru-Vue relief globe.

The globe is reproduced in 12 color tones, and measures over 12 inches in diameter at sea level and almost 13 inches in diameter at high elevations. Circumference is 3 feet.

Readers' Service Item 44

Reinforced Hose

A nylon inner tube reinforced with high tensile strength yarn distinguishes Nylaflow pressure hose, currently available from Polymer Corp. of Pennsylvania. Designed for use in such applications as hydraulic, lubrication, hot paint, solvent, and freon lines, it is reported to have only one-fifth the weight and one-half the wall thickness of rubber hose with equivalent burst strength.

Test data indicate the hose exhibits outstanding resistance to flex, pressure-pulse, and vibrational fatigue. It is unaffected by caustics and most organic solvents, but is not recommended for use in mineral acids above 5% concentration.

The hose retains flexibility and toughness in temperature down to —65° F. Maximum constant operating temperature is 200° F.; intermittent operating temperature is 300° F. Two types of hose, with recommended maximum operating pressures of 1250 and 2000 psi. (5000 and 8000 psi. burst strengths, respectively), are supplied in inside diameter sizes ranging from ⅛ through ½ inch.

Readers' Service Item 45

Reinforced Plastic Pontoons

By using reinforced plastic pontoons, designers of the floating salt water marina at Long Beach, Calif., have eliminated the long-standing problems of corrosion and electrolytic decay. The material is a maintenance-free resin developed by Minnesota Mining and Manufacturing, reinforced with glass fibers and preform molded in matched metal dies by Zenith Plastics Co. The 3M resin is reported to resist, besides corrosion and electrolytic decay, interior condensation of moisture, growth of marine animals, attack by gasoline and oils, and moisture absorption. Its comparatively light weight eases installation.

In addition, this flotation system can be moved to suit the needs of marine expansion. Not only can it be enlarged, but the entire layout can be modified.

The pontoons are designed with inverted ribs to provide extra strength in critical stress areas. They are molded in halves and joined with high strength epoxy cement.

For the original installation, the pontoons are placed on a template which indicates proper spacing; the walkway and finger sections are lowered over them with a crane; the pontoons are temporarily secured in position; and the entire unit is hoisted into position in the boat basin. After removal of the temporary clamps, the pontoons float free under the walkway or finger.

Inverted rib design pontoon.

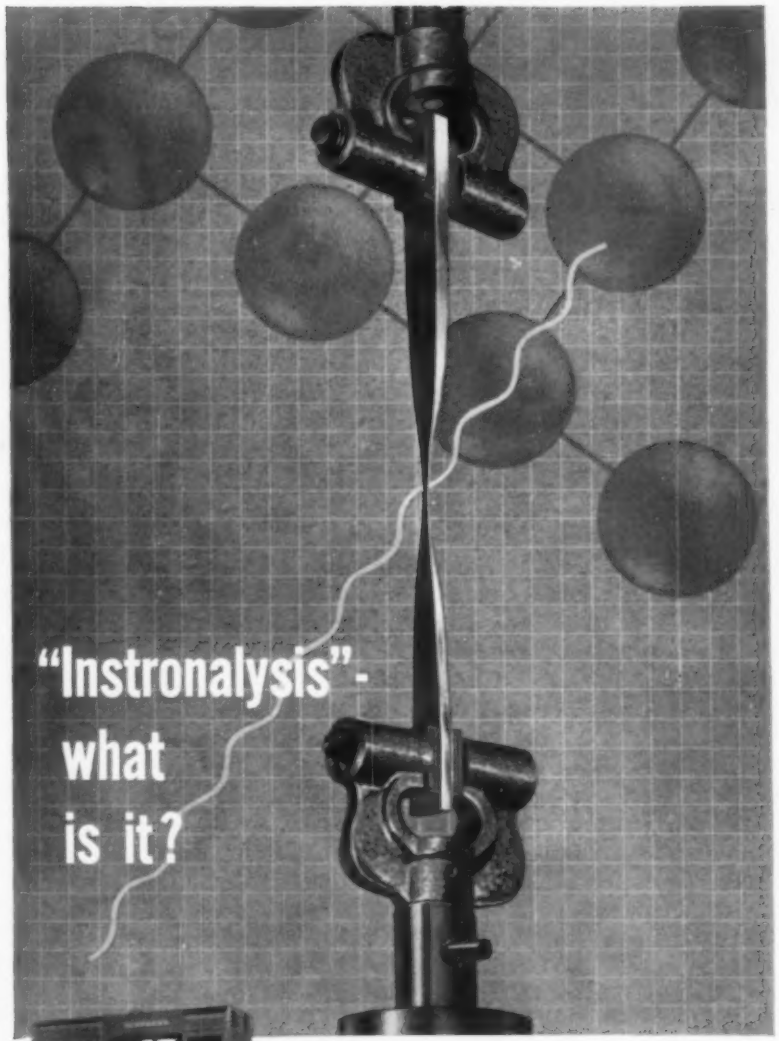
Readers' Service Item 46

Cabin Cruiser

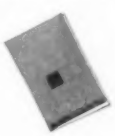
Lunn Laminates, Inc., is marketing as a proprietary item a 19-foot cabin cruiser molded of fiberglass laminates with polyester resins. The Sea Lass features, among other things, foam flotation, two bunks, and a built-in five gallon water tank.

The outboard-inboard motor boat is supplied with an 80 hp. Volvo-Penta Aquamatic transmount motor.

Readers' Service Item 47



The Instron comes in various models and sizes, to suit the widest applications — for tests under all sorts of environmental conditions. ILLUSTRATED: **FLOOR MODEL**—load ranges from 2 grams to 10,000 lbs.



Interesting studies on the rheological properties of viscoelastic materials are available in Bulletin PC-2 and R-3. Reprints on many other fields of testing are also available for the asking.

"Instronalysis" means in-depth testing of materials with the Instron Universal Tester. You won't find the word in Webster's, but it is a term of importance to every laboratory concerned with modern testing techniques.

That's because today's technology demands nothing less than in-depth testing. Stress-strain curves alone are no longer adequate to measure the characteristics of long-chain molecular materials and other new "miracle" products. Today's tester must be able to determine the effect of different strain rates at various temperatures, energy loss under repeated cycling, stress relaxation and recovery, recoverable and unrecoverable creep, and many more characteristics beyond the scope of conventional equipment.

"Instronalysis" brings together both routine and advanced testing techniques within easy reach of a single instrument. It's what we mean when we say "You can do more with an Instron."

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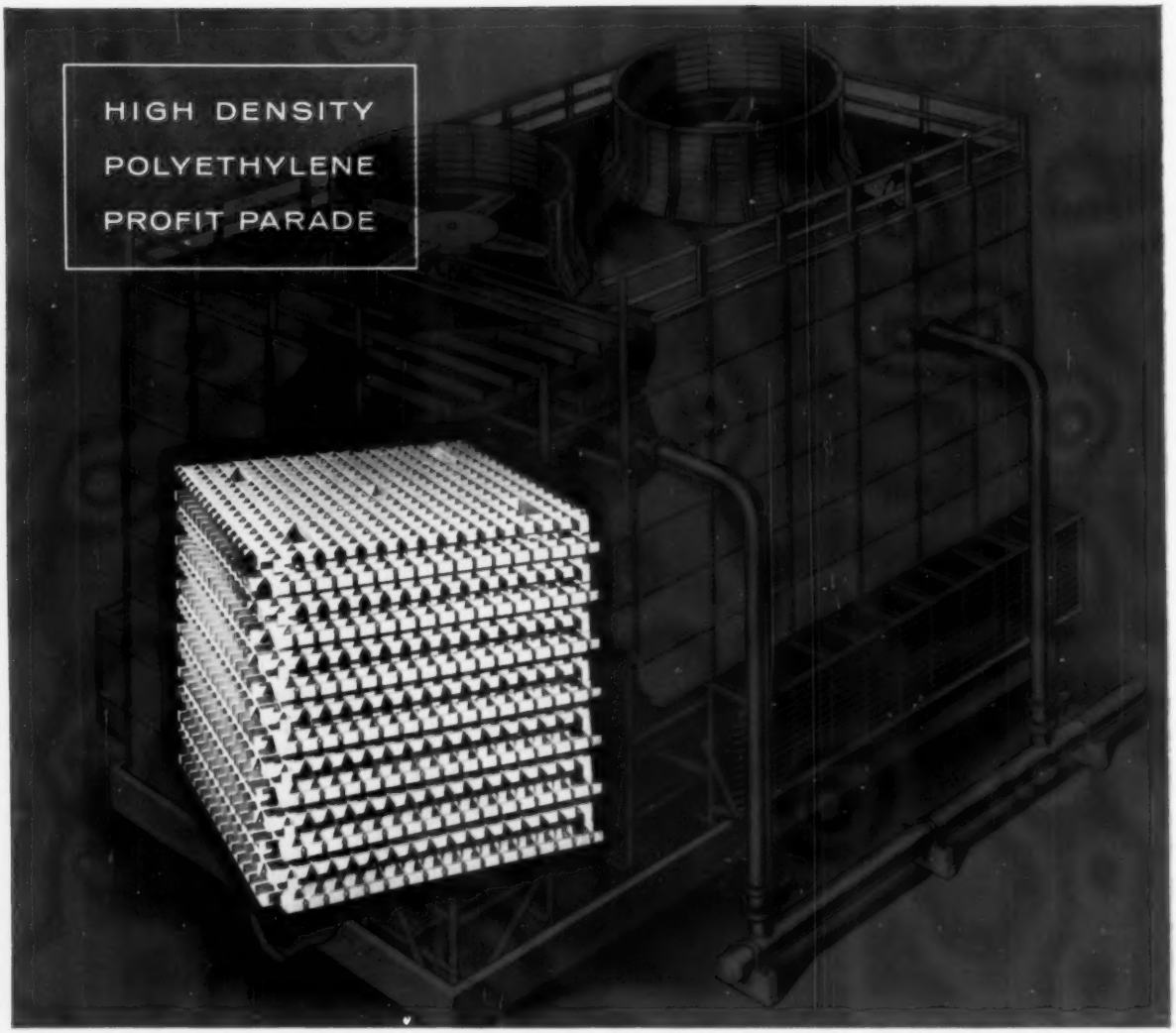


MOLDED BY GENERAL AMERICAN TRANSPORTATION COMPANY, CHICAGO, ILLINOIS

New Plastic Cooling Tower Grids Last Longer—Cool Better

Are you working on a new way to improve the performance of your products? Grex high density polyethylene could be the best material for your application, just as it is for the superior cooling tower grids developed by Fluor Products Company.

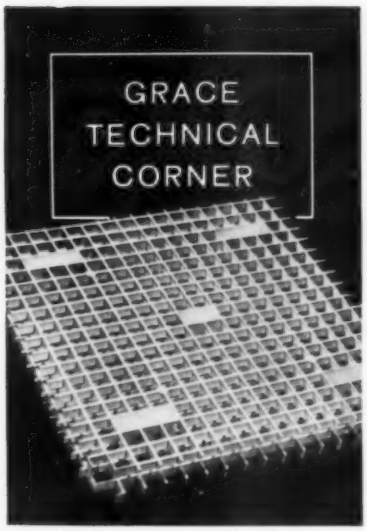
Fluor "Poly-Grid" takes the place of a wooden egg crate construction in film-type tower packing. As water cascades through this type of packing it is broken into a continuous film to permit evaporation and cooling. Efficiency is improved by increasing the surface area of the packing with thinner strips and more spaces between them. This principle is applied by "Poly-Grid" to provide more cooling per cubic foot than any other packing.

The grids molded of Grex are designed for use in water cooling systems contaminated by chemicals. This Grace plastic is impervious to corrosive action of most chemicals. The grids utilize the strength and rigidity of Grex in moldings that cover an area of up to 9 square feet. They are light in weight. Compared to wooden tower packing, they require far less maintenance and are much more durable. As Fluor engineers put it, "Poly-Grid" can be considered to have a longer service life than any other cooling tower fill material now in use.

Find out more about high density polyethylene for improved products in your field by calling in the experts. Grace has the production facilities, technical service and experience to help put your products in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY



How do chemicals affect Grex?

From the standpoint of resistance to chemical attack, high density polyethylene is perhaps the most versatile plastic available today for consumer and industrial products. Grex withstands staining, embrittlement, permeation, softening and distortion when exposed to many different liquids and gases normally harmful to other materials. A key reason why Fluor chose Grex for "Poly-Grid" is the fact that it cannot be damaged by such chemicals as hydrocarbons present in industrial water cooling systems. Similar problems have been solved for a wide range of other products by specifying this plastic. Here are a few examples.

Industrial chemicals. Five-gallon carboys for shipment of virtually all corrosive alkalies and acids are made of high density polyethylene.

Agricultural chemicals. A fertilizer spreader for home gardeners and a fitting for an agricultural sprayer are made of Grex to withstand attack of agricultural chemicals.

Salt water. Marine rope, a fishing tackle box and a marine battery case are made of high density polyethylene to withstand harmful effects of sodium chloride and other chemicals in salt water.

Petroleum products. A jerry can blow molded of high density polyethylene is unaffected by most petroleum products.

Chlorine. The valve for a home swimming pool chlorine pump utilizes Grex to resist corrosion.

Get more details. Send for the new Grace Technical Service Bulletin, No. 104, "Chemical Resistance of Grex." And remember that Grace is ready and willing to provide technical assistance for your high density polyethylene projects. Bring us into your picture soon.

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

Polyethylene Pressure Tape

The plastics division of Visking Co., division of Union Carbide Corp., has introduced a pressure tape made of its Visqueen polyethylene film. The tape will adhere to almost any film, wood, or metal, and can be used in sealing, patching, or seaming operations.

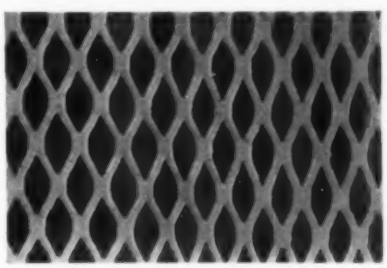
Available in transparent or black rolls two inches wide by 100 feet long, the tape is supplied in a tear-off container. The adhesive surface is protected by a backing of specially-treated paper which is stripped off in a continuous motion as the tape is applied. It forms an especially strong bond when used in conjunction with conventional polyethylene film.

Readers' Service Item 48

Non-Woven Netting

Perforated and expanded polyethylene and polypropylene is available in commercial quantities from Reeves Brothers, Inc. Expanded polyolefin begins as a flat strip extrusion ¼ inch thick and 10 inches wide. It is then flattened and perforated with staggered rows of slits. When the material is pulled at right angles to the slits, it opens into a web or netting.

The expanded polyolefins are presently available in a width of 22-24 inches. Both the polyethylene and polypropylene can be stabilized against ultraviolet degradation for extended outdoor use. There are 1.23 yards per pound, and since the specific gravity is less than one, the material floats. Breaking strength in the filling direction (axis of elongation) is 40 psi., and in the warp direction, 100 or more. Elongation is 10-15% in the warp and about 100% downward in the filling.



Expanded polyolefin netting.

Readers' Service Item 49

Epoxy-Glass Cargo Carrier

A reinforced plastics cargo carrier, built with a spray gun and capable of transporting a 40,000 pound payload by rail, motor, or ship, has been announced by Union Carbide Plastics Co. Of epoxy-glass fiber construction, the container, weighing 2,800 pounds, is 24 feet long, eight feet wide, and eight feet high.

Reinforced plastic cargo carrier.

Characterized by structural strength and rigidity, the carrier can be bulk loaded and then lifted by straddle carrier or ship's crane to a railroad flat car, flat-bed motor carrier, or shipboard. The cargo carriers can be stacked five high for ship transport.

The prototype carrier consists of built-up epoxy-glass fiber panels, 4 by 8 feet in size, bonded to a steel frame. In future models, it is estimated that about half the weight of the steel frame, or about 500 pounds, can be saved by eliminating the floor frame and using a monolithic, all epoxy-glass floor instead of panels bolted to the metal frame.

The 4- by 8-foot section has a central corrugated sheet of epoxy-glass fiber, together with a skin of the same material bonded to both sides. The corrugated sheet is 0.08 inch thick and the flat skin 0.1 inch thick. The entire panel assembly is about two inches thick and weighs 64 pounds. After the panels are bonded to the steel frame, manhole covers are installed, intake and dumping spouts added, and an epoxy gel coat sprayed over the entire surface.

Readers' Service Item 50

Pipe Fitting Insulation

Fit-rite insulation for standard pipe fittings has been made available in four thicknesses: ½ inch, 1 inch, 1½ inches, and 2 inches; by Fibrous Glass Products, Inc. Molded of a fiberglass-reinforced low molecular weight phenolic, the fittings come in two accurately molded halves which fit together instantly. The insulation is installed with staples, soft wire, or tape; and once in place, can be finished with canvas or vapor barrier casings.

Readers' Service Item 51

New Literature

For more information check Readers' Service Card (p. 77)

"Tonox—Curing Agent for Epoxy Resins." Bulletin C-103. Naugatuck Chemical, Division of U. S. Rubber Co. 7 pages. This mixture of aromatic polyamines is reported to impart high heat distortion properties, good chemical resistance, and good electrical properties to cured castings and laminates. Calculations, toxicology, pot life, and viscosity are discussed.

Readers' Service Item 61

"Polyglas for Greenhouses." Poly-Fact Data File H-1. American Polyglas Corp. 2 pages. Light transmittance, strength, color, maintenance, ventilation, heating, and construction of reinforced plastic panels with respect to greenhouse requirements are stated.

Readers' Service Item 62

"Plastic and Chemical Materials." General Electric Co. 12 pages. The catalog describes and specifies polycarbonate resins; phenolic molding powders, resins, and varnishes; and fused magnesium oxide. Application and design possibilities are included.

Readers' Service Item 63

"Uni-Mulsion Water-Base Baking Finishes." Universal Paint and Varnish, Inc. 4 pages. This brochure discusses uses and advantages of this coating, which may be applied as a primer or as a single coat.

Readers' Service Item 64

"Naugatuck Plastics Resin Guide: 1959-1960." Naugatuck Chemical Division, U. S. Rubber Co. 8 pages. Properties, features, and applications, of Kralastic resin-rubber compounds, Vibrin liquid polyesters, and Marvinol PVC's are tabulated.

Readers' Service Item 65

"Standards for Plastic Injection and Compression Molding." Detroit Mold Engineering Co. 4 pages. Standard mold components and hardware are illustrated.

Readers' Service Item 66

"Chemtube—Epoxy Fiberglass Seamless Tube." Technical Bulletin MSD-54A,B. Chemfab Corp. 2 pages. The sheets discuss specifications and properties of this rigid electrical insulating material with continuous braided fiberglass sleeving. Other products briefly mentioned are Chemrod (epoxy with fiberglass filament), Chemtube silicone and urethane fiberglass tubing for Class H and Class F applications, and Chemtube with metal interlayers or lining of Teflon.

Readers' Service Item 67

"Facts on Phenolics." Durez Plastics Division, Hooker Chemical Corp. 15 pages. Properties of Durez molding powders and physical and electrical characteristics of molded materials are tabulated. The materials are classified by outstanding properties. Three diallyl phthalates are included.

Readers' Service Item 68

"Plastics for Science and Industry." Catalog No. 959. Bel-Art Products. 32 pages. Illustrations and specifications of industrial plastic equipment such as flasks, tubing, scoops, racks, boxes, pumps, and tanks are provided.

Readers' Service Item 69

"Rotary Paddle Feeder." Products Data Sheet 5901. Richardson Scale Co. 2 pages. Specifications of the 18- and 30-cubic foot paddle feeders for use with granular or non-flushy ground materials of grain size less than $\frac{1}{32}$-inch, are given.

Readers' Service Item 70

"Low Viscosity PVC Resins." Escambia Chemical Corp. 4 pages. These resins may be formulated for flooring, injection molding, rigid and semi-rigid, and coating applications. The bulletin includes sample formulations and property tables on four Escambia resins.

Readers' Service Item 71

"Colors for Every Purpose." Catalog R. Pylam Products Co. 6 pages. The bulletin lists colors and dyes, including pigments for polystyrene, intended for the small volume user. The firm also supplies harmless colors and pigments for toys.

Readers' Service Item 72

"Marvinol Cold Dry Blend Vinyl Resins for Calendering." Naugatuck Chemical Division, U. S. Rubber Co. 3 sheets. Data sheets supply general information, plus resin and compound properties of Marvinols VR-31, VR-33, and VR-34.

Readers' Service Item 73

"Ultrasonic Cleaning Primer." National Ultrasonic Corp. 12 pages. This pamphlet introduces nomenclature, equipment, techniques, and applications of ultrasonic cleaning. Various detergents and cleaning compound formulations are described.

Readers' Service Item 74

"Machining Thermoplastics." Cadillac Plastic Co. 8 pages. The bulletin outlines recommended procedures (sawing, routing, drilling, turning, shearing, punching, grinding, and finishing) for machining and finishing thermoplastic sheets, rods, and tubes. Special machining characteristics of acrylics, nylon, fluorocarbons, and polyethylene are featured.

Readers' Service Item 75

"Mycalex News." Mycalex Corp. of America. 8 pages. The first issue of this house organ features an article on the origin of synthetic mica and news about the company's personnel and activities.

Readers' Service Item 76

"Heat Seal Characteristics of Polyethylene Films and Coated Substrates." U. S. Industrial Chemicals Co. 15 pages. This brochure describes the machine conditions for satisfactorily heat sealing polyethylene. Factors discussed include machine, resin, and film characteristics.

Readers' Service Item 77

"Generalized Product Information About the Versatile New Epoxy Painting Material, Samrand Plastic Coating." Samrand, Inc. 9 pages. Samrand, a modified amine-cured epoxy, may be sprayed or brushed onto concrete, metal, or interior wood surfaces. The bulletin describes applications, techniques for use, and case histories.

Readers' Service Item 78

"Acton Fluoroetch Solution." Acton Laboratories. 3 pages. Technical data sheets outline procedures and precautions for handling the solution, which is used to form an adhesive-bondable film on fluorocarbons. After dipping, spraying, brushing, or spotting, the etching solution should remain in contact with the polymer surface for 2-15 seconds.

Readers' Service Item 79

"Plastic Forming and Packaging Equipment." Atlas Vac-Machine Corp. 4 pages. Two machines, Z-21 for average plastic sheet forming, and J-36 for techniques other than straight vacuum or vacuum drape, are discussed. Each machine is available in four degrees of automation.

Readers' Service Item 80

"Bulk Handling Methods." Spencer Chemical Co. 12 pages. This illustrated booklet details four of the most commonly used methods of bulk handling: palletized bags, expendable bulk containers, returnable bulk containers, and Dry-Flo cars. Also shown are the equipment required, investment necessary, and a formula for evaluating the need for this equipment.

Readers' Service Item 81

"Foster Grant has a new, low price for Nylon-6, and here's why," *says Joe Foster*

WE DIDN'T WAIT for Nylon-6 to become a large volume molding resin before we reduced the price. We simply did what we believed in—lowered the price of our 60 series of Fosta® Nylon resins from $1.18 per pound to as low as *$.98 per pound*. Now, no one responsible for the design, development and manufacture of molded products can afford not to consider Nylon-6 as a basic, efficient and profitable fabricating material.

Experience both as raw material suppliers and proprietary molders tells us that Nylon-6 has a wonderfully promising future. For example: Housings for portable electric radios, for home electric appliances, for hand power tools and important components such as gears, rods, tubes and plates and countless other molding applications haven't even been tapped yet.

Nylon-6 is one of the *great* molding resins. It provides toughness, non-flammability, superb molding

ease, abrasion-resistance and colorability by pigmenting or dyeing. It also possesses good electrical properties, is impact-resistant, light-stable, self-lubricating, flexible and has excellent heat stability. In short, Nylon-6 can do almost anything a molded product might require.

Our confidence in Nylon-6 is supported further by what certainly is a trend toward still lower material prices. One obvious indication is that within the last three years, caprolactam monomer—the basic ingredient of Nylon-6—has come down more than 20%. The next two or three years should bring even lower caprolactam prices and wider and more varied use of Nylon-6 in end product applications everywhere.

Faith in the future of Nylon-6 prompts us to take this major step in making this great molding resin more available than ever before to the plastics industry. We would like to make Fosta Nylon more familiar to you by sending you our completely new price list and brochure and by discussing your molding operation and Nylon-6 requirements with you. Just call or write Foster Grant, Leominster, Mass., KEystone 4-6511. We're ready to work with you and your staff right now!

FG

FOSTER GRANT

Your Partner in Plastics Progress

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in principal cities

Patent Digest

Materials

Styrene Polymers. No. 2,889,311. E. C. Chapin and R. I. Longley, Jr., Springfield, Mass. (to Monsanto Chemical Co., St. Louis, Mo.).

Alkyd Resins Modified with Mono-Allyl Maleate End Groups. No. 2,889,312. A. Szayna, Passaic, N. J. (to U. S. Rubber Co., New York, N. Y.).

Method and Composition for Curing Epoxy Resins. No. 2,891,927. J. Philipson, Pasarena, Calif. (to Chemical Process Co. San Francisco, Calif.).

Copolymer of Difluorovinyl Chloride and Vinyl Acetate. No. 2,891,934. J. F. Olin, Ambler, Pa. (to Pennsalt Chemicals Corp.).

Compositions of Polystyrene and Natural Rubber/Methyl Methacrylate Graft Copolymers and Process of Producing Same. No. 2,891,018. J. J. Millane, Birmingham, England (to Distillers Co., Ltd., Edinburgh, Scotland).

Polymers of Vinylidene Monomers, Destaticized with N,N,N',N' Tetrakis (2-Hydroxypropyl) Ethylene Diamine. No. 2,891,028. See also No. 2,891,029, -030, -031, and -032. M. A. Coler, Scarsdale and A. S. Louis, Riverdale, N. Y.

Polyethylene Compositions Containing Certain Ethynyl Alcohols. No. 2,891,036. C. L. Stacy, Jr., and R. F. Monroe, Midland, Mich. (to Dow Chemical Co., Midland, Mich.).

Resinous Mixtures Containing Vinyl Chloride-Octyl Acrylate Interpolymers and Acrylonitrile-Styrene Copolymers. No. 2,889,308. H. A. Fedderson, Metuchen, N. J. (to Union Carbide Corp.).

Composition Containing an Alkyd Resin and a Polyamide Resin Derived from Polymeric Fat Acids and an Alkylene Polyamine. No. 2,889,292. D. E. Peerman, Minneapolis, Minn. (to General Mills, Inc.).

Acrylonitrile Polymer Composition Stabilized with Tetrakis Hydroxymethyl Phosphonium Chloride and a Method of Making Same. No. 2,889,303. H. D. De Witt, New Wilmington, Pa. (to Chemstrand Corp., Decatur, Ala.).

Composition Comprising a Vinyl Monomer and a Polyester of a Polyhydric Alcohol, an Unsaturated Acid, a Saturated Acid and a Hexahalocyclopentadine Adduct and Laminated Article Containing Same. No. 2,890,144. P. Robitschek, Wilson, and C. T. Bean, Niagara Falls, N. Y. (to Hooker Chemical Corp., Niagara Falls, N. Y.).

Vinyl Chloride Polymers Plasticized with a Condensate of a Tetrahydrofurfuryl Ester of a Monoolefinic Monocarboxylic Acid and a Dialkyl Fumarate. No. 2,889,-300. See also 2,889,301 and -302. J. Dazzi, Dayton, O. (to Monsanto Chemical Co., St. Louis, Mo.).

Vinyl Halide Polymers Stabilized with Phosphites and Benzoic Acid Esters. No. 2,889,295. J. R. Darby, Webster Groves, and P. R. Graham, Richmond Heights, Mo. (to Monsanto Chemical Co., St. Louis, Mo.).

Cured Polypropylene. No. 2,890,187. L. W. Bowman, Westfield, R. F. Leary, Cranford, and W. J. G. McCulloch, Plainfield, N. J. (to Esso Research and Engineering Co.).

Polyvinyl Chloride Resin-Urea-Clay Composition and Method of Making Same. No. 2,890,190. R. Van Volkenburgh, Borger, Tex. (to J. M. Huber Corp., Borger, Tex.).

Chloroethylene Polymer Stabilized with 1,2-Epoxypropan-3-one Derivatives. No. 2,890,200. R. L. Hudson, Midland, Mich. (to Dow Chemical Co., Midland, Mich.).

Composition Containing Halogenated Vinylidene Resin Plus Non-Volatile Liquid Monophenyl Alkane Plasticizer. No. 2,885,378. J. R. Darby, Webster Groves, Mo. (to Monsanto Chemical Co., St. Louis, Mo.)

Flame Resistant Composition Comprising Chlorinated Polyester Resin, Inorganic Oxide and an Epoxide Resin and Method of Preparing. No. 2,885,380. V. D. Elarde, Schiller Park, Ill. (to Western Electric Co., Inc., New York, N. Y.).

Solid Polyethylene Plastic Materials. No. 2,886,471. C. R. Bruce, Wembdon, Bridgwater, and T. N. Williams, Bridgwater, England (to British Cellophane Ltd., Bridgwater, England).

Polyamide Resin. No. 2,886,543. D. E. Peerman and H. Wittcoff, Minneapolis, Minn. (to General Mills, Inc).

Printed copies of patents are available from the Commissioner of Patents, Washington 25, D. C. Prices, 25c each.
—The Editor

Alkyd Resins from Hexahydrokojic Acid. No. 2,886,544. A. Bavley, Brooklyn, and C. J. Knuth, Flushing, N. Y., and P. D. Thomas, Groton, Conn (to Chas. Pfizer & Co., Inc., New York, N. Y.)

Thermoplastic Composition Plasticized with a Mixed Diester Plasticizer of an Aliphatic Diol Having Two Primary Alcohol Groups. No. 2,886,545. P. H. Rhodes and P. L. Imes, Cincinnati, O.

Composition Comprising a Vinylidene Chloride Polymer and an Esterified Polyether Plasticizer. No. 2,886,548. D. I. H. Jacobs, Aigburth, Liverpool, England (to Distillers Co., Ltd., Edinburgh, Scotland).

Aluminum-Modified Phenolic Resins. No. 2,886,554. F. Schlenker, Wiesbaden, Germany (to Chemische Werke Albert, Wiesbaden-Biebrich, Germany).

Stabilized Ethyl Cellulose Hot Melt Compositions. No. 2,887,396. R. M. Krajewski and H. C. Kelly, Midland, Mich. (to Dow Chemical Co., Midland, Mich.).

Cellulosic Coatings for Vinyl Copolymers. No. 2,887,397. N. H. Johnson, Atlanta, Ga., and C. H. Coney, Kingsport, Tenn. (to Eastman Kodak Co., Rochester, N. Y.).

Thixotropic Resin Composition Comprising an Unsaturated Alkyd Resin, Styrene and Silica Aerogel. No. 2,887,461. E. V. Hort, Westfield, N. J. (to Celanese Corp. of America, New York, N. Y.).

Composition Comprising Copolymers of Methyl Methacrylate and a-Methylstyrene with Polymers of Acrylic Esters. No. 2,887,464. H. W. Coover, Jr., and W. C. Wooten, Jr., Kingsport, Tenn. (to Eastman Kodak Co., Rochester, N. Y.).

Equipment

Film Slip Tester. No. 2,887,874. R. S. Mason, Midland, Mich. (to Dow Chemical Co., Midland, Mich.).

Apparatus for Plasticizing a Solid Particulate Material for Extruding or Molding. No. 2,887,719. H. Corbett, Worcester, Mass. (to Package Machinery Co., E. Longmeadow, Mass).

Apparatus for Moulding Plastic Materials. No. 2,885,734. R. Wucher, St. Ouen, France.

Feeding Device for Calenders. No. 2,886,847. B. F. Herr, Manheim Tp., Lancaster Ct., Pa. (to Armstrong Cork Co., Lancaster, Pa).

Method and Means for Producing Reinforced Plastic Structures. No. 2,887,721. S. Blanchi, Le Vesinet, and R. Lacour, Paris, France.

Heating Element for Plastic. No. 2,886,850. I. B. Kubiliunas, S. Boston, Mass.

Apparatus for the Manufacture of Hollow Articles Composed of a Plastic Material. No. 2,887,716. E. Crosio, Milan, Italy (to Pirelli Societa per Azioni, Milan, Italy).

Means for the Transporting of Thermoplastic Materials in Bulk. No. 2,887,251. M. J. Mackridge, Manchester, England (to Technical Waxes, Ltd., Manchester, England).

Heat Sealing Packaging Machine. No. 2,882,662. S. J. Campbell, Green Bay, Wis. (to Food Machinery and Chemical Corp., San Jose, Calif.).

Plastic Bag Making Machine. No. 2,882,956. H. C. Weist, Louisville, Ky.

Device for Adapting a Tubular Blank to a Shaping Mandrel. No. 2,890,482. A. Quinche, St. Sulpice, Switzerland (to American Can Co., New York, N. Y.).

Injection Molding Machine. No. 2,890,488. G. W. Gemberling, Melrose Park, Ill. (to Richardson Co., Melrose Park, Ill.).

Machine for Forming Plastic Containers. No. 2,890,483. L. D. Soubier, Toledo, O. (to Owens-Illinois Glass Co.).

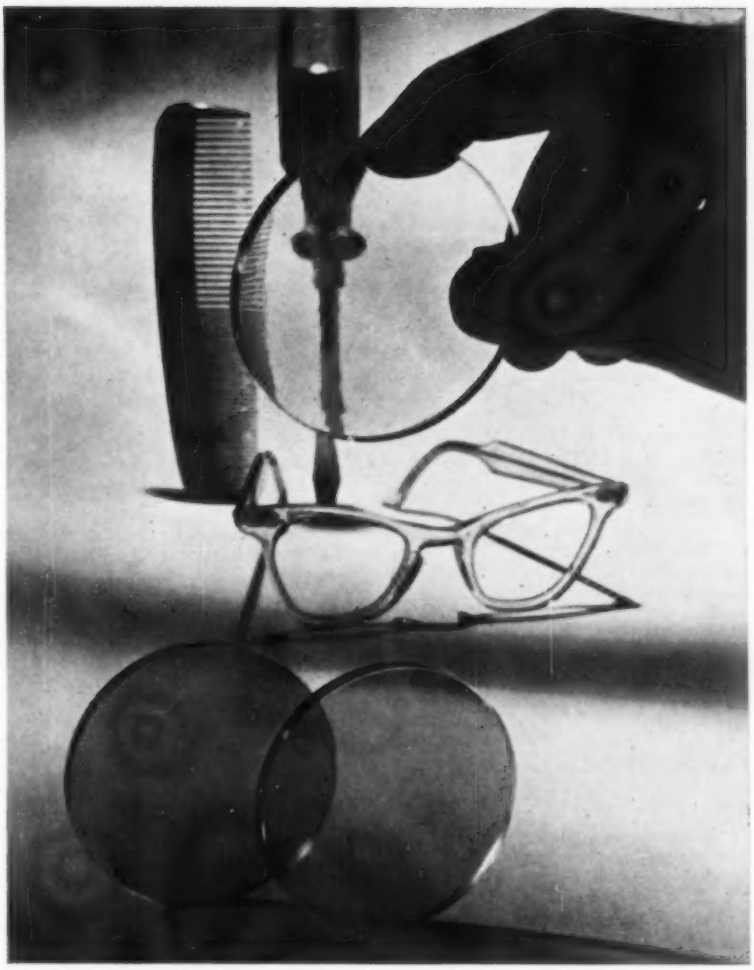
Rotary Molding Device. No. 2,891,281. E. E. Heinzelman, Manheim Tp., Lancaster Ct., Pa. (to Armstrong Cork Co., Lancaster, Pa.).

Molding Apparatus for Making Small Plastic Articles. No. 2,891,282. I. M. Neitlich, Stamford, Conn. (to Cue Fastener, Inc.).

Apparatus for Moving Tubular Structures Through a Processing Station. No. 2,888,710. M. B. Mueller, Upper Providence, Pa., and B. S. Penley, Bergenfield, N. J. (to Allied Chemical Corp., New York, N. Y.).

Apparatus for Molding Parts Having Irregular Outer Surfaces. No. 2,891,283. T. K. Cramer, Norwichtown, and A. M. Chabotte, Norwich, Conn. (to Plastene Corp., Crawfordsville, Ind.).

Transfer Molding Apparatus. No. 2,883,704. H. F. Jurgeleit, Oceanside, N. Y. (to U. S. Rubber Co., New York, N. Y.).



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Article Abstracts

Materials

"The Environmental Behavior of Plastics," Sidney Levy, PLASTICS WORLD, 18, 3, 26 (March 1960).

Discussion of the hows and whys of plastics-environment interactions.

"Epoxy Resin Laminates with High Thermal Resistance," R. O. Menard and W. W. Cooner, SPE J., 16, 3, 277 (March 1960).

Condensation of a 16th ANTEC paper dealing with PMDA as a cross-linking agent that imparts high-temperature strength and stability to cured epoxies.

"New Curing Agents for Epoxy Resins," Henry Lee and Kris Neville, SPE J., 16, 3, 315 (March 1960).

Test results obtained with boron-containing complexes are given.

"Cure of Molded Melamine Resin and its Significance for Properties," H. P. Wohnsiedler and R. A. Tiley, SPE J., 16, 3, 299 (March 1960).

A 16th ANTEC paper dealing with two tests for cure.

"Polypropylene Wax — A New Resin for Plastic and Coating Applications," J. E. Guillet and H. W. Coover, Jr., SPE J., 16, 3, 311 (March 1960).

The synthesis, properties, and applications for wax-like polymers from propylene are described

"Acrylic Polymers for Use in Rigid and Semi-Rigid Vinyl Compounds," R. P. Hopkins, SPE J., 16, 3, 304 (March 1960).

A 16th ANTEC paper describing new polymer systems.

"Thermal and Shear Degradation in Polyethylene Extrusion," Hans Schott and W. S. Kaghan, MODERN PLASTICS, 37, 7, 116 (March 1960).

An SPE ANTEC paper showing that most polyethylene degradation is thermal in character.

"Rheological Study of Vinyl Calendering Compounds," W. E. Walstenholme and P. E. Roggi, MODERN PLASTICS, 37, 7, 131 (March 1960).

A relationship is proposed for optimum calendering of plasticized vinyl compounds.

"Olefin and Terpene Epoxides," R. J. Gall, J. J. Rizzo, and H. M. Castrantas, MODERN PLASTICS, 37, 7, 137 (March 1960).

Based on an SPE RETEC paper given in 1958.

"Effects of Thermal History on Some Properties of Polyethylene," J. B. Howard and W. M. Martin, SPE J., 16, 4, 407 (April 1960).

How theoretical studies can lead to information of value to fabricators.

"Recent Developments in Rigid Urethane Foams," L. R. LeBras, SPE J., 16, 4, 420 (April 1960).

A brief discussion of the properties and suggested applications for the foams.

"Causes of Melt Fracture," R. M. Schulken and R. E. Boy, Jr., SPE J., 16, 4, 423 (April 1960).

How melt fracture of polymers is related to extrusion behavior.

"An Analysis of Injection Mold Filling of Polyethylene," R. B. Staub, SPE J., 16, 4, 429 (April 1960).

Existing flow-theory can be applied to injection mold filling.

"Light Stable Polystyrene Widens Lighting Applications," P. H. Estes and L. E. Tallman, WESTERN PLASTICS, 7, 3, 41 (March 1960).

A short review of the properties of Styron Verelite resins.

"One-Shot Urethane Foams of Polyethers—New Use for Versatile Organo-Tins," G. P. Mack, CHEMICAL PROCESSING, 23, 4, 30 (April 1960).

A description of one-shot polyether urethane foams.

"Structural Design of Plastics," E. Baer, J. R. Knox, T. J. Linton, and R. E. Maier, SPE J., 16, 4, 396 (April 1960).

A general discussion of plastics properties suitable for design use.

"Thermal Considerations in Mold Design," W. J. B. Stokes, SPE J., 16, 4, 417 (April 1960).

Emphasis on heat control as an important factor in mold design.

"Evaluation Tests for Plastics Heels," E. E. Joiner, J. P. Szumski, and F. J. McGarry, MODERN PLASTICS, 37, 7, 152 (March 1960).

Tests for studying materials, processing techniques, shoe manufacturing operations, and reinforcement methods.

"Molded Screw Caps," E. C. Emanuel, PLASTICS WORLD, 18, 4, 26 (April 1960).

The concluding part of a review of thermoplastic and thermoset capping materials.

Equipment

"Automatic Delayed Action Stripping and Ejection." I. Mombacher, PLAST-VERARBEITER, 10, 6, 206 (June 1959).

The construction and method of operation are described for a fully-automatic mold equipped with both stripper plate and ejector with delayed action. (In German.)

"Preplasticizing in Injection Molding," E. G. Fisher and W. A. Maslen, BRIT. PLASTICS, 32, 9, 417; 32, 10, 468; 32, 11, 516 (Sept., Oct. & Nov. 1959).

The aim of this survey is to collate the scattered available information on preplasticizers, and examine it critically and impartially. The principles of preplasticizing and its development first are discussed; plunger- and screw-type machines and equipment in current use next are dealt with; and, finally, existing systems are compared and requirements of an ideal system proposed.

"A Segel-type Plastometer," R. Rolff, PLASTICA 12, 6, 448 (June 1959).

The Segel plastometer, designed in 1903 for determining viscosity of sealing wax and later used for bitumen compounds, consists essentially of a cylinder moving coaxially within another cylinder. A Netherlands firm has found that a modified Segel-type plastometer also is useful for studying synthetic resin adhesives. The operation of the device is described, and calculations are detailed by which viscosity and a modulus of sliding are derived from measured forces and movements. (In Dutch.)

"Modernization Program for Thermosetting Plastics Equipment," E. G. Greninger, SPE J., 16, 3, 285 (March 1960).

A brief discussion of five areas that affect costs of molded items.

"Extruder Instrumentation," H. B. Kessler, R. N. Bonner, P. H. Squires, and C. F. Wolf, SPE J., 16, 3, 263 (March 1960).

Condensation of a 16th ANTEC paper covering temperature and pressure recorders possessing rapid response.

"Designing Thermoforming Molds for Linear Polyethylene," Robert Doyle and D. E. Allison, SPE J., 16, 3, 263 (March 1960).

Condensation of a 16th ANTEC paper dealing with mold design.

Addresses of magazines abstracted, scheduled to appear this month, will be in the July issue.

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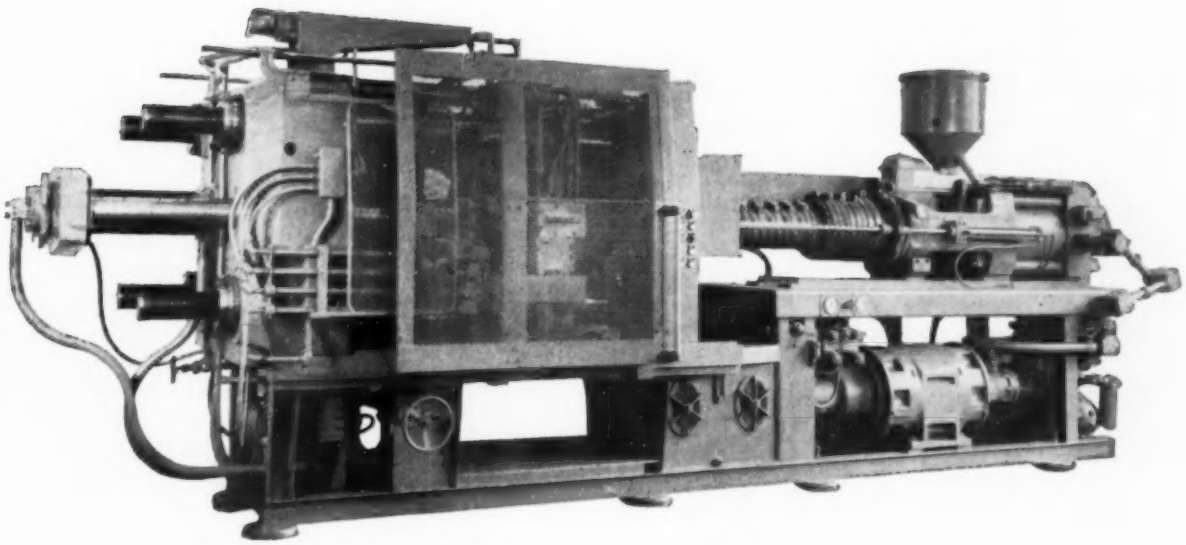

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Current Market Prices

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Food Machinery & Chemical Adipol BCA, ODY, XX, 2EH, 10A	lb.	$ .40	/	$ .475
Butyl oleate and stearate	lb.	.26	/	.27
Di-carbitol phthalate	lb.	.48	/	.505
Di-iso-butyl adipate	lb.	.41	/	.45
Di-iso-decyl phthalate	lb.	.26	/	.30
Dinopol IDO	lb.	.255	/	.295
MOP	lb.	.275	/	.315
Dioctyl phthalate	lb.	.25	/	.29
DIOP	lb.	.25	/	.29
Kapsol	lb.	.33	/	.355
KP-20	lb.	.25	/	.29
-23	lb.	.235	/	.335
-90	lb.	.40	/	.435
-140	lb.	.46	/	.485
-201	lb.	.45	/	.465
-260	lb.	.34	/	.375
Kronisol	lb.	.35	/	.385
Kronitex 1, AA, K-3, MX	lb.	.325	/	.36
Methox	lb.	.385	/	.41
Ohopex Q-10	lb.	.265	/	.305
R-9	lb.	.3525	/	.3775
Tributyl phosphate	lb.	.50	/	.535
Harchem butyl oleate	lb.	.24	/	.33
Butyl stearate, tech.	lb.	.2225	/	.3125
Harflex 110, 130	lb.	.2650	/	.4050
120, 150, 180	lb.	.26	/	.40
140	lb.	.2750	/	.4150
210, 250	lb.	.40	/	.495
370	lb.	.8075	/	.895
375	lb.	.7425	/	.83

Resins & Molding Compounds

Epoxy

Ren materials	lb.	.72	/	1.95

Phenolic

Fiberite FM 509	lb.	.36	/	.37
1957	lb.	.40	/	.50
2488	lb.	.98	/	1.05
3510X-688 black -868, -1233	lb.	.415	/	.42
4032X-3152, -3270	lb.	1.36	/	1.41
5967	lb.	.45	/	.48
7850 red	lb.	.48	/	.50
14482	lb.	.415	/	.42

Polyethylene

Marlex 1478, 2030, 2278, 2331, 2380, 2420, 2520, 2950	lb.	.325	/	.365
1703	lb.	.365	/	.405
3328	lb.	.35	/	.39
5003 ¡5005, 5003, 5005, 5012, 5002, 6009, 6015	lb.	.38	/	.42
Plain colors and high dispersion black	lb.	.44	/	1.01
General purpose black	lb.	.405	/	.445
5040, 5065, 6035, 6050	lb.	.35	/	.39
Plain colors and high dispersion black	lb.	.41	/	.98
General purpose black	lb.	.375	/	.415
TR-101, natural and black	lb.	.40	/	.44
Standard white	lb.	.41	/	.45
Plain colors	lb.	.46	/	1.03
TR-201, -202, natural	lb.	.38	/	.42
Black	lb.	.44	/	.48
Plain colors	lb.	.44	/	1.01
TR-212, -213	lb.	.38	/	.42
TR-603, natural; TR-615, black	lb.	.345	/	.385
TR-822, natural	lb.	.325	/	.365

CALENDAR of COMING EVENTS

June 20-24
Gordon Research Conferences. Elastomers—Structure and Properties. Colby Junior College, New London, N. H.

July 4-8
Gordon Research Conferences. Polymers. Colby Junior College, New London, N. H.

July 19-21
Western Packaging & Materials Handling Exposition. Pan Pacific Auditorium, Los Angeles, Calif.

September 8-9
SPE Eastern New England Section RETEC. Vinyl Plastics and Plastics in the Shoe Industry. Statler-Hilton Hotel, Boston, Mass.

September 22
SPE Binghamton Section RETEC. Plastics in Business Machines. Sheraton Inn, Binghamton, N. Y.

September 27-29
Technical Association of the Pulp and Paper Industry. Eleventh Annual Testing Conference. Pantlind Hotel, Grand Rapids, Mich.

October 9-12
ASME Rubber and Plastics Conference. Lawrence Hotel, Erie, Pa.

October 13-14
SPI Sixteenth Annual New England Section Conference. Wentworth-by-the-Sea, Portsmouth, N. H.

October 14-23
French Packaging Institute. First International Packaging Machinery Show. Autopac 1960. Paris, France.

October 17-19
International Congress, 1960, on the Technology of Plastics Processing. Royal Institute for the Tropics, Amsterdam, Holland.

October 17-19
Technical Association of the Pulp and Paper Industry. Fifteenth Plastics-Paper Conference. Hotel Syracuse, Syracuse, N. Y.

October 19
SPE New York Section RETEC. Tooling for the Plastics Industry. Hotel Commodore, New York, N. Y.

October 19-26
International Plastics Exhibition. macroPlastic 1960. Croeselaan Exhibition Grounds. Utrecht, The Netherlands.

Domestic Production and Sales of Plastics and Resin Material, January and February, 1960

Following are the partly estimated and revised statistics for the domestic production and sale of plastics and resinous material during the months of January and February, 1960. Units listed are in pounds, dry basis unless otherwise specified. Data on alkyds and rosin modifications have not been included since their use is primarily limited to the protective coating industry.

	January, 1960		February, 1960	
	Production	Sales	Production	Sales
Cellulose Plastics:				
Cellulose acetate and mixed ester:				
Sheets, under 0.003 gage	1,465,699	1,225,321	1,272,383	1,365,356
Sheets, 0.003 gage and over	1,676,767	1,362,519	1,598,239	1,610,949
All other sheets, rods, and tubes (including other cellulose plastics)	752,901	726,645	818,681	884,536
Molding and extrusion materials (including other cellulose plastics)	7,724,267	7,528,024	8,256,662	8,099,421
Nitrocellulose sheets, rods, and tubes	217,352	123,736	231,569	125,375
TOTAL	11,836,986	10,966,245	12,177,534	12,085,673
Phenolic and Other Tar-Acid Resins:				
Molding materials	19,442,274	16,498,997	20,429,113	16,778,239
Bonding and adhesive resins for—				
Laminating (except plywood)	6,429,305	4,098,492	6,311,765	4,199,804
Coated and bonded abrasives	1,293,538	1,381,375	1,616,061	1,348,517
Friction materials (brake linings, clutch facings, and similar materials)	971,214	1,073,975	1,429,527	1,175,906
Thermal insulation (fiber glass, rock wool)	4,025,379	3,888,694	3,552,607	3,469,834
Plywood	4,672,187	3,958,310	5,484,435	4,897,466
All other bonding and adhesive uses	5,933,417	5,822,145	5,701,675	6,658,663
Protective-coating resins unmodified and modified except by rosin	1,892,543	1,697,782	2,440,370	1,931,613
Resins for all other uses	4,554,024	4,081,124	4,284,771	3,796,976
TOTAL	49,213,881	42,500,893	51,250,324	44,255,018
Urea and Melamine Resins:				
Textile-treating and textile-coating resins	2,889,612	2,621,929	2,466,644	2,711,946
Paper-treating and paper-coating resins	1,188,852	1,993,865	2,531,555	2,285,222
Bonding and adhesive resins for—				
Laminating	2,652,879	2,258,716	3,270,182	2,525,305
Plywood	8,623,366	8,260,945	8,499,333	8,881,705
All other bonding and adhesive uses	1,828,250	1,817,854	1,382,294	1,638,094
Protective-coating resins, straight and modified	3,106,555	2,590,511	3,331,281	2,469,637
Resins for all other uses, including molding	10,346,321	9,743,354	10,959,744	10,759,645
TOTAL	31,635,835	29,286,974	32,441,033	31,271,554
Styrene Resins:				
Molding and extrusion materials:				
Straight polystyrene	22,950,572	17,233,783	21,297,975	20,067,417
All other	35,505,796	27,390,228	32,327,082	26,654,149
Protective-coatings	6,601,715	5,620,480	6,059,179	5,537,155
Textile and paper treating and coating resins	6,323,426	4,496,666	5,401,076	4,432,932
All other uses	11,935,066	15,911,037	14,522,455	18,533,235
TOTAL	83,316,575	70,652,194	79,607,767	75,224,888
Vinyl and Vinyl Chloride Resins:				
Polyvinyl chloride and copolymer resins (50% or more PVC) for—				
Film (resin content)		8,628,172		9,044,419
Sheeting (resin content)		10,414,005		10,381,577
Molding and extrusion (resin content)		21,300,457		24,234,098
Textile and paper treating and coating (resin content)		5,109,495		5,019,054
Flooring (resin content)		12,988,629		13,721,632
Protective coating (resin content)		2,707,895		2,601,714
All other uses (resin content)		8,352,121		7,584,981
All other vinyl resins for—				
Adhesives (resin content)		4,551,349		4,810,963
Protective coatings (resin content)		1,923,444		1,929,497
All other uses (resin content)		10,509,983		11,919,120
TOTAL	102,179,124	86,485,550	101,254,980	91,247,055
Coumarone-Indene and Petroleum Polymer Resins				
Polyester Resins:	19,367,665	19,757,770	19,393,879	20,078,448
For reinforced plastics	11,521,003	9,568,587	12,142,406	11,402,529
For all other uses	2,634,160	2,017,892	2,317,483	1,975,677
TOTAL	14,155,163	11,586,479	14,459,889	13,378,206
Polyethylene Resins:				
For film and sheeting		28,620,905		31,728,541
Molding materials		11,527,780		14,964,131
Extrusion materials		10,930,345		12,597,557
For all other uses		33,277,944		36,045,198
TOTAL	113,006,260	84,356,974	105,663,437[1]	95,335,427[1]
Epoxy Resins:				
For protective coatings		2,286,700		1,890,241
For all other uses		2,585,802		2,329,181
TOTAL	4,694,196	4,872,502	4,857,463	4,219,422
Miscellaneous Synthetic Plastics and Resin Materials, Including Silicone Resins	24,086,215	20,174,359	24,714,504	21,683,929
GRAND TOTALS	453,491,900	380,639,940	445,820,810	408,779,620

[1] 11.4% produced by the low-pressure process.

SOURCE: United States Tariff Commission, Chemical Division.

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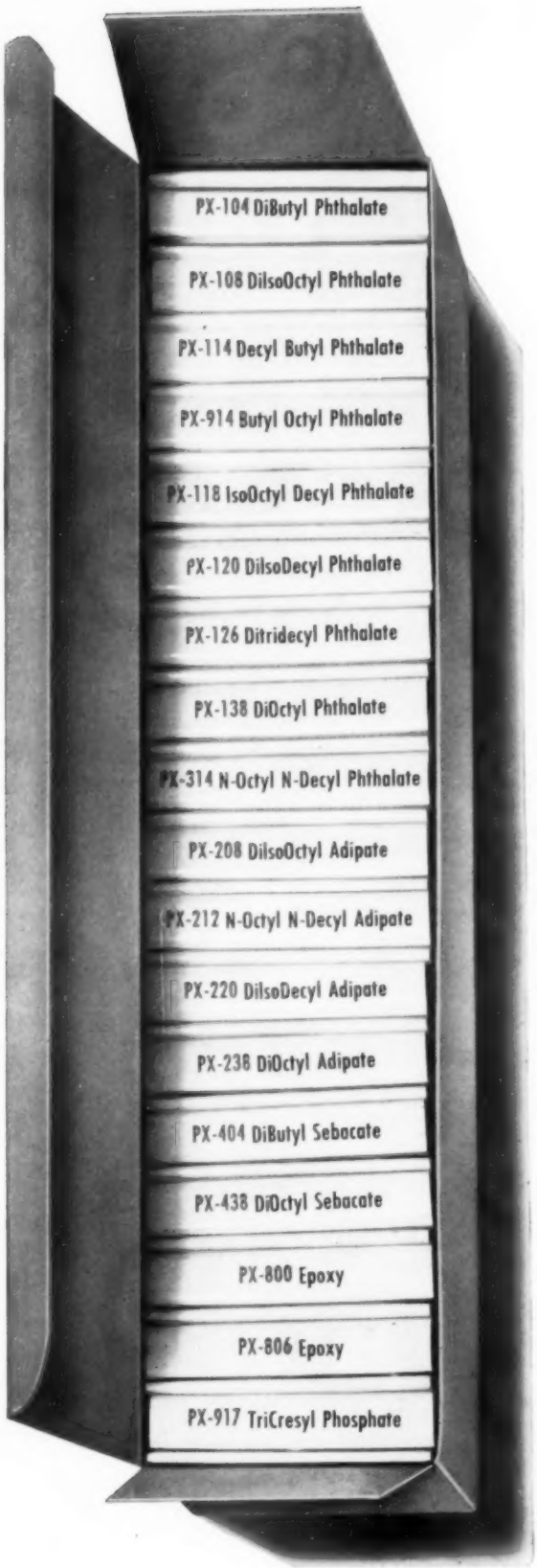

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